

89-04517/



This report is being released simultaneously by the Forest Engineering Research Institute of Canada as Special Report SR-46

FRDA REPORT 016

**SITE PREPARATION EQUIPMENT IN
BRITISH COLUMBIA**

CURRENT AVAILABILITY AND FUTURE NEEDS 1/

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September, 1987

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ISSN 0835 0752

ACKNOWLEDGEMENTS

The author is indebted to representatives of the forest industry, government, and the equipment industry for advice, data, and comments on mechanical site preparation. Their names are listed in Appendix VI.

The author is also indebted to Lorne Bedford of the BCMFL Silviculture Branch, Victoria, for advice and information on regional site preparation programs, additional information sources, and a review of the draft report.

Alex Sinclair and Ingrid Hedin of FERIC also provided valuable review comments and suggestions.

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SUMMARY

The purpose of this project was to investigate the quantities, kinds, and potential sources of mechanical site preparation (MSP) equipment available in British Columbia in relation to the MSP work planned.

On B.C. Crown lands, an estimated 66 300 ha of "current" MSP and 38 700 ha of "rehabilitation" MSP are planned for each year during the period 1988-92. Taking into account annual equipment productivities, added work on federal and private lands, machine replacements and other factors, it is estimated that existing pieces of MSP equipment must be supplemented with 93 new pieces by the 1988 field season. The new equipment needed will consist of: 60 brush blades or rakes; 21 pieces of major MSP equipment (rotary cultivators, brushcutters, mowers, patch scarifiers, and disc trenchers); and 12 MSP attachment kits for small excavators. The estimated purchase cost of this new equipment is \$2.2 million at 1987 prices.

Prime movers for the new MSP equipment must also be purchased or diverted from other work. Experienced MSP operators or well-trained new operators will be required.

Cost and technical problems encountered with current equipment are outlined, along with possible solutions in some cases. Some of the new equipment now available or becoming available is described in the context of B.C. conditions. Several Canadian equipment suppliers and manufacturers are also profiled.

Neither B.C. alone nor Canada alone can form an attractive market for Canadian manufacturers of major MSP equipment during the 1988-92 projection period. To succeed, a Canadian manufacturer's product would need to capture at least a substantial share of the entire North American market.

Most MSP work during 1988-92 will be done by MSP contractors who own multi-purpose prime movers and borrow, lease, or buy MSP attachments as required. Canadian and British Columbia equipment firms can find opportunities in adapting factory prime movers for MSP roles, and in manufacturing improved MSP attachments for them. Many firms in Western Canada already function similarly for equipment users in construction, logging, mining, and agriculture. Several of these would benefit from a diversification into mechanical site preparation. Communications between such firms, the equipment users, and the forest managers will ensure steady improvement in the equipment itself and the quality of MSP work.



INTRODUCTION

The preparation of a forest site for restocking is the first in a series of steps leading to establishment of a new timber crop. The wide range of climatic, edaphic, and terrain conditions and of ecosystems in British Columbia calls for a correspondingly wide range of site preparation techniques and equipment.

Occasionally, the harvesting process itself prepares the site adequately by accident or design, but often the lack of additional treatment has led to delays, disappointments, or the need for costly rehabilitation. Broadcast burning after logging is traditional in B.C. and will remain common where terrain or debris preclude other methods. Modern burning techniques are fast, precise, and effective, but have ceased to be cheap, still depend on weather, may damage soils or adjacent timber, and may cause objectionable smoke buildups. Where permitted, herbicides are useful in site preparation, but usually in combination with burning or mechanical treatment rather than alone. The remaining important alternative is mechanical site preparation (MSP).

MSP is prescribed variously to improve such microsite conditions as soil structure, temperature, moisture regime, aeration, light, or frost response; and if planting is required, to improve access and planting-spot choices for the planters. Particularly on the better growing sites, these improvements often make the difference between success and failure in restocking.

The quantity of MSP work done under the jurisdiction of the British Columbia Ministry of Forests and Lands (BCMFL) has risen sharply during the 1980s, reaching over 36 000 ha on Crown lands in 1985-86¹. This figure includes only MSP work on recent cutovers, known as "current" work. In addition, "site rehabilitation" work, mostly mechanical, was done on about 16 000 ha of NSR or NCC² Crown lands in the same year, for a total of 52 000 ha. By 1987-88, the corresponding volume of MSP work is expected to rise to about 58 000 ha of "current" and 33 100 of "site rehabilitation", for a total of 91 100 ha³. Combined MSP under these programs is projected to stay at that level until 1991-92.

New MSP equipment will be required to support this ambitious program. Correct choices of equipment types will be important. The purposes of this project are to:

¹BCMFL Silviculture Branch, draft material for 1985-86 Annual Report.

²NSR: Not satisfactorily stocked. NCC: Noncommercial cover.

³Estimates of the MSP portion of all site preparation on Crown lands, as developed in Table 3 below.

1. review the site preparation equipment now in use in B.C. and project what will be needed in the near future;
2. identify problems with current types, and suggest improvements;
3. list the machines currently available (North American and overseas sources) and their specifications; and
4. identify opportunities for Canadian manufacturers to build and sell site preparation equipment in Western Canada.

1. SURVEY OF EXISTING EQUIPMENT BY TYPE

Almost without exception, MSP equipment consists of an implement or attachment mounted on or drawn by a prime mover. Typically, the prime movers used are borrowed from construction, logging, or land-clearing and returned when the MSP work is completed. Crawler tractors, wheeled skidders, excavators, and other prime movers suitable for MSP are numerous and widely distributed throughout B.C. While it is important to use the best prime mover for the application, prime movers are seldom the limiting factor. The amount of MSP equipment available is thus usually defined by the numbers of MSP attachments available, not by the numbers of prime movers.

Two detailed reports on mechanical site preparation equipment were consulted, both Canada-wide in scope. First, the Canadian Pulp and Paper Association survey of silvicultural equipment (1985) gives good detail on the MSP equipment used by member companies participating in the survey. However, few B.C. companies are CPPA members and no government or contractor equipment is included. Second, a comprehensive printout was obtained from the CFS Mechanization of Silviculture Equipment Information Bank (Richenhaller, pers. comm., Dec., 1986). While the Bank contains detailed information on a large number of types and makes of MSP machines, it was not designed to record numbers of units in the field.

The Northern Silviculture Committee reported about 35 pieces of major* MSP equipment in north central B.C. in 1984 (Coates and Haeussler, 1984). To include all of B.C., BCMFL personnel in Victoria, each of the six Forest Regions, and many Forest Districts were asked to update the listing for Ministry units, and also to suggest further contacts. Forest company users confirmed company-owned equipment. Major silviculture contractors gave similar information. The main Canadian suppliers of MSP equipment were consulted as a cross-check on past sales to B.C. and for technical information on their current products. A listing of survey contacts is shown in Appendix VI.

*Excluding drag-scarification combinations, bulldozer blades or rakes, and home-built plows.

Table 1 is the result of this search, tabulated by forest region and ownership category. Briefly summarized, the types and pieces of equipment owned and located in B.C. are as follows:

1.1 Rotary Cultivators	2
1.2 Rotary Brush Cutters	3
2.0 Moulder/Inverters	4
3.0 Patch Scarifiers	13
4.0 Disc Trenchers	9
5.0 Choppers, Crushers	2
6.0 Plows	27
7.0 Excavator-Mounted Scarif./Mounders	3
8.0 Bulldozer Blades	(160)
9.0 Drag Scarifier Combinations	(50)
10.1 Downing Cable/Chain	2
10.2 Ripper + Anchor Drag	1
10.3 V-Plow + Leno or Ripper	2
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This is not a complete and accurate list of all equipment available for MSP work in B.C. for several reasons:

1. Attachments such as anchor chain and barrel drags, brushblades, and rakes are often home-built, and are virtually uncountable. The true numbers of these items must be at least as high as the numbers listed above, particularly in the case of bulldozer blades, which have many non-forestry uses.
2. Prime movers such as crawlers, skidders, and small excavators, and implements like breaking plows, Madges, or Hydro-Axes are already working in logging, mining, land-clearing, right-of-way clearing, and construction. MSP work could become a welcome part of their workload, given proper scheduling, operator training, and contract rates.
3. The list covers only equipment owned in B.C. It is feasible and may become common to lease or rent specialized equipment from outside B.C.

2. ESTIMATE OF FUTURE REQUIREMENTS

The foregoing estimate of the existing population of MSP equipment in B.C. must be examined against the amounts and kinds of MSP work being planned, in order to judge the needs for additional equipment.

Some MSP will undoubtedly take place on federal government and private forest lands. The bulk of the MSP work, however, will be on Provincial Crown lands. B.C. Ministry of Forests and Lands reports and projections are the logical source of information on these Crown lands.

TABLE 1. Listing of Mechanical Site Preparation Equipment
Owned and Located in British Columbia--December, 1986.

[illegible]

ATTACHMENT (Type, Examples)	PRIME MOVERS	MOUNT (FRONT, REAR, BOOM, TOWED)	PIECE COUNT BY REGION AND TYPE OF OWNER																	
			CAR		KAM		NEL		PG		PR		VAN		BC					
			FS	LI	OT	FS	LI	OT	FS	LI	OT	FS	LI	OT	FS	LI	OT	ALL		
7.0 Excavator-mounted patch scarifier/mounders (rake or bucket)	50-80 kW excavator (150 kW PWC)	boom				1									2		3	3		
8.0 Bulldozer (or skidder) blades:																				
8.1 Toothed brush blade or rake (Beales, 6-Way, 4-Way, Eden, Baumfritz)	100-250 kW crawler	C-frame	1			5			8	5				1	2		3	9	10+ 22+	
8.2 Straight or modified factory blade (e.g. B.C. coast, Alberta For. Serv.)	100-250 kW crawler	C-frame												1			1		1+	
9.0 Drag scarifier combinations (anchor chain, spikes, cat-pads, shark-fin barrels, all home-built)	100-150 kW skidder, 100-250 kW crawler	towed (2 to 5 rows)	3	8		3	2	3	3	7	9	6		3	1		21	24	3	48
10.0 Other:																				
10.1 Downing cable or chain (e.g. BCPS)	250 kW crawlers, abreast	rear, winch									1					2			2	
10.2 Ripper + "anchor" drag (e.g. Evans Prod., Savona)	150 kW crawler	rear, towed				1											1		1	
10.3 V-plow combinations (e.g. V-plow + Leno or ripper, etc.)	100-250 kW crawler	plow front, rest rear				1								1			1	1	2	

FS = B.C. Forest Service LI = Licensee-owned
OT = Other (independent contractors, equipment owners)

Table 2, summarized from BCMFL data compiled for the 1985-86 Forest Service Annual Report, shows the distribution of all site preparation work for that year by type, including MSP, prescribed burning, and other methods. Numbers of hectares treated are shown for each Forest Region, by method. The figures include 91 420 ha of site preparation done under "basic silviculture" but exclude 16 039 ha of site rehabilitation done under "intensive silviculture" within the federal-provincial FRDA program. Percentages corresponding to the hectares are also shown, and these percentages give some picture of the distribution of all site preparation done that year, including MSP work by broad groupings (Bunch, Drag, Blade scarify, and Other MSP). "Other MSP" is reported to include work by the Marden brush chopper, Leno scarifier, V-plow, disc trencher, Bracke scarifier, ripper plow, backhoe and Bracke moulder, while "Chem., Snags, etc." includes site preparation with herbicides, snag-falling, knockdown of NCC, and mistletoe control.

It should be emphasized that there are few typical years in site preparation. The main preoccupation in 1985-86 was suppression of wildfires, with understandably less emphasis on MSP or prescribed burning.

In December, 1986 the Forest Service completed a series of projections outlining all silviculture activities, basic and intensive, starting with 1986-87 and continuing for each year until 1991-92. After rapid expansion in the first two years, the entire program, including site preparation (basic) and site rehabilitation (intensive) was projected to remain virtually constant from 1988-89 on. The site preparation and site rehabilitation programs under this steady state called for 142 000 and 35 418 ha, respectively, each year on provincial Crown lands⁵. Table 3 is developed using these numbers of hectares, by region, with the percentages developed in Table 2 as a rough guide. Basic mechanical site preparation is labelled "Current" (C) and Intensive mechanical site preparation as "Rehab." (R).

Table 3 is an estimate of the amounts (hectares) of mechanical site preparation required each year from 1988 on, distributed amongst the different equipment types⁶. The next step, translating this estimate of hectares into a corresponding estimate of machines required, involves assigning values for the capabilities of each machine, and is shown in Table 4. Since the calculations include 10 equipment types, 6 regions, and current vs. rehab., they are detailed and lengthy. Estimates of shifts per year (SH/Y) are considered realistic for the coming years (although a trend toward double-shifting or long shifts beyond 8 hours of high-cost equipment has been noted and would permit increases). Machine availability (M.A.) and productivity (HA/PMH) estimates are based on Coates and Haeussler (1984), and are believed realistic for estimating purposes.

⁵In March, 1987 the BCMFL reduced the annual Basic site preparation goal by 4% from 142 200 to 136 500 ha. Since the change is small and possibly temporary, since the estimates which follow are subject to other major uncertainties, and since the object of the estimates is to predict equipment needs conservatively, this reduction has been ignored.

⁶"Other equipment (10.0 in Table 1) is disregarded as unnecessary (e.g. downing chain) or is merged with similar equipment under the other headings.

TABLE 2. Areas and Percentages by Site Preparation Treatment.
 (Source: BCFS, draft 1985-86 annual report data.
 Crown land, current only, site preparation for natural
 or artificial regeneration.)

REGION	BURN, BDCST, SPOT	CHEM, SNAGS, ETC.	MECHANICAL SITE PREPARATION				ALL MSP	TOTAL TREATED
			BUNCH	DRAG	BLADE SCAR.	OTHER MSP		
CAR ha	1776	38	790	1172	7	3493	5462	7276
%	25	0	11	16	0	48	75	100
KAM ha	3083	611	1751	643	1296	843	4533	8227
%	38	7	21	8	16	10	55	100
NEL ha	2865	269	2146	393	527	332	3398	6532
%	44	4	33	6	8	5	52	100
PG ha	23843	4774	4251	7064	3779	3042	18136	46753
%	51	10	9	15	8	7	39	100
PR ha	8720	152	928	337	175	3101	4541	13413
%	65	1	7	3	1	23	34	100
VAN ha	3803	5034	17	-	19	347	383	9220
%	41	55	0	0	0	4	4	100
BC ha	44090	10877	9883	9609	5803	11158	36453	91420
%	48	12	11	11	6	12	40	100

TABLE 3. Estimate of Hectares per Year of Mechanical Site Preparation by Equipment Type (Crown Lands, Constant Level, 1988-92 Period).

REGION	CURRENT/ REHAB.	TOTAL HA/YR TREAT- MENTS	1.1 Rotary culti- vator	1.2 Rotary brush- outlet	2.0 Moulder	3.0 Patch scarif.	4.0 Disc trch.	5.0 Chopper	6.0 Plow	7.0 Excav. patch scarif.	8.0 Bunch, blade	9.0 Drag, scarif.	ALL HSP (ha)	HSP/ TOTAL TREAT- MENTS (\$)
CAR	C	14300	-	-	300	1260	400	-	1000	300	900	2140	6300	44
	R	3800	-	-	-	380	570	100	380	-	2770	-	4200*	-
KAM	C	23500	-	-	-	1175	1175	-	1175	-	8695	1880	14100	60
	R	4600	-	-	-	-	500	-	330	-	2670	-	3500	-
NEL	C	15900	-	-	-	700	500	-	-	100	4000	1100	6400	40
	R	7300	-	-	-	-	100	50	360	100	5890	-	6500	-
PG	C	48500	-	-	1820	1820	2300	-	900	900	7760	6800	22300	46
	R	14300	170	120	200	260	700	200	1940	380	10530	-	14500*	-
PR	C	21800	-	-	200	1650	1700	-	800	200	2950	300	7800	36
	R	4000	-	60	100	160	-	-	400	80	2200	-	3000	-
VAN	C	12500	-	-	-	120	-	-	-	380	600	-	1100	9
	R	1400	-	100	-	-	-	-	-	200	1100	-	1400	-
BC	C	142200	-	-	2320	6725	6075	-	3875	1880	24905	12220	58000	41
	R	35400	170	280	300	800	1870	350	3410	760	25160	-	33100	-

* "ALL HSP" may exceed "TOTAL TREATMENTS" because site rehabilitation may include multiple HSP treatments on the same hectare.

TABLE 4. Numbers of Machines for 1988-92 Mechanical Site Preparation Goals (Crown Lands).

EQUIPMENT	C/R	REQ.	HA/YR REQ'D	MACHINE CAPABILITY			NO.OF MACH. REQ'D
				SH/Y	M.A.	HA/PMH	
1.1 Rotary Cult- ivators	C	(NIL)					
	R	PG	170	60	.70	.2	67 2.5
1.2 Rotary Brush Cutters	C	(NIL)					
	R	PG	120	60	.70	.3	101 1.2
		PR	60	60	.70	.2	67 .9
		VAN	100	80	.65	.2	83 1.2
			<u>280</u>				<u>3.3</u>
2.0 Mounders	C	CAR	300	60	.75	.8	288 1.0
		PG	1820	60	.75	1.0	360 5.1
		PR	200	60	.75	1.0	360 .6
			<u>2320</u>				<u>6.7</u>
	R	PG	200	60	.75	1.0	360 .6
		PR	100	60	.75	1.0	360 .3
			<u>300</u>				<u>.9</u>
	C	CAR	1260	100	.75	1.1	660 1.9
		KAM	1175	100	.75	1.0	600 2.0
		NEL	700	80	.75	.9	432 1.6
3.0 Patch Scar- ifiers		PG	1820	100	.75	1.1	660 2.8
		PR	1650	100	.75	1.1	660 2.5
		VAN	120	140	.70	.8	627 .2
			<u>6725</u>				<u>11.0</u>
	R	CAR	380	100	.70	1.0	560 .7
		PG	260	100	.70	1.0	560 .5
		PR	160	100	.70	1.0	560 .3
			<u>800</u>				<u>1.5</u>
	C	CAR	400	100	.75	1.2	720 .6
		KAM	1175	100	.75	1.0	600 2.0
4.0 Disc Trench- ers		NEL	500	100	.75	.8	480 1.0
		PG	2300	100	.75	1.0	600 3.8
		PR	1700	100	.75	1.0	600 2.8
			<u>6075</u>				<u>10.2</u>
	R	CAR	570	100	.75	1.0	600 1.0
		KAM	500	100	.75	1.0	600 .8
		NEL	100	100	.75	.8	480 .2
		PG	700	100	.75	1.0	600 1.2
			<u>1870</u>				<u>3.2</u>
	C	(NIL)					
5.0 Choppers	R	CAR	100	100	.75	.6	360 .3
		NEL	50	80	.75	.5	240 .2
		PG	200	100	.75	.6	360 .6
			<u>350</u>				<u>1.1</u>
	C	(NIL)					

EQUIPMENT	C/R	REQ.	HA/YR REQ'D	SH/Y	MACHINE CAPABILITY			NO. OF MACH. REQ'D
					M.A.	HA/PMH	HA/ MACH./ YR.	
6.0 Plows	C	CAR	1000	100	.75	.7	420	2.4
		KAM	1175	100	.75	.7	420	2.8
		PG	900	100	.75	.7	420	2.1
		PR	800	100	.75	.7	420	1.9
			3875					9.2
	R	CAR	380	100	.75	.6	360	1.1
		KAM	330	100	.75	.6	360	.9
		NEL	360	100	.75	.6	360	1.0
		PG	1940	100	.75	.6	360	5.4
		PR	400	100	.75	.6	360	1.1
			3410					9.5
7.0 Excavators, Patch Scarif.	C	CAR	300	100	.75	.4	240	1.2
		NEL	100	100	.75	.3	180	.6
		PG	900	100	.75	.4	240	3.8
		PR	200	100	.75	.3	180	1.1
		VAN	380	140	.75	.3	252	1.5
			1880					8.2
	R	NEL	100	100	.75	.3	180	.6
		PG	380	100	.75	.4	240	1.6
		PR	80	100	.75	.4	240	.3
		VAN	200	140	.75	.3	252	.8
			760					3.3
8.0 Crawler or Skidder Blades	C	CAR	900	120	.75	.6	432	2.1
		KAM	8695	120	.75	.6	432	20.1
		NEL	4000	100	.75	.4	240	16.7
		PG	7760	100	.75	.4	240	32.3
		PR	2950	100	.75	.4	240	12.3
		VAN	600	160	.75	.3	288	2.1
			24905					85.6
	R	CAR	2770	120	.75	.4	288	9.6
		KAM	3680	120	.75	.4	288	9.3
		NEL	5890	120	.75	.4	288	20.5
		PG	10530	120	.75	.4	288	36.6
		PR	2200	120	.75	.3	216	10.2
		VAN	1100	180	.75	.3	324	3.4
			25030					89.6
9.0 Drag Combin- ations	C	CAR	2140	120	.80	1.0	768	2.8
		KAM	1880	120	.80	1.0	768	2.4
		NEL	1100	120	.80	1.0	768	1.4
		PG	6800	120	.80	1.0	768	8.9
		PR	300	120	.80	1.0	768	.4
			12220					15.9
	R (NIL)							
TOTALS	C		58000					146.8
	R		33100					114.9
COMBINED	C + R		91100					261.7

The estimates in Table 4 need further adjustments to account for:

- MSP planned for federal government and private lands (about 5% of the area planted in recent years has been on these lands, mostly in the Vancouver Region);
- normal equipment replacements as existing and purchased equipment wears out;
- the extent of double-shifting expected (more with costlier equipment); and
- the "convenience" factor, to reflect a tendency to acquire surplus machines and attachments to avoid excessive moving between projects and lost opportunities during good weather periods.

Table 5 shows the factors applied to each equipment type and the final numbers of machines after all adjustments.

When the numbers in Table 5 are compared with the numbers collected during the survey of existing equipment, the results can be summarized as follows:

Equipment	Projected 1988	Have Now	Needed 1988
1.1 Rotary Cultivators	3	2	1
1.2 Rotary Brush Cutters	5	3	2
2.0 Moulder/Inverters	10	4	6
3.0 Patch Scarifiers	18	13	5
4.0 Disc Trenchers	16	9	7
5.0 Choppers, Crushers	1	2	-
6.0 Plows	27	27	-
7.0 Excavator-Mounted Scarif./Mounders	15	3	12
8.0 Bulldozer Blades/Rakes	220	(160)	60
9.0 Drag Scarifier Combinations	<u>28</u>	<u>(50)</u>	<u>-</u>
TOTALS	343	273	93*

* Totals add down but not across because some items, e.g. choppers and drags, are in surplus.

This summary clearly requires further comment to avoid misinterpretations:

- Items 1.0 to 4.0: These are the major, specialized pieces of mechanical site preparation equipment, of which 31 are listed for B.C. now and 21 more are listed as needed. Some of the existing machines will require replacement within 1 or 2 years.

TABLE 5. Numbers of Machines for 1988-92 MSP, Adjusted For:
MSP on Private and Federal Lands;
Machine Replacements;
Anticipated Double-Shifting; and
"Convenience" Factor.

TYPE	UNADJ. NO'S (TABLE 4)	ADD PRIVATE AND FEDERAL LANDS (FACTOR)	REPLACEMENT: MACH. LIFE, (YRS) (FACTOR)	DOUBLE- SHIFTING (FACTOR)	"CONVENIENCE" (FACTOR)	NEW NO. OF MACHINES	ROUNDED-UP NO. OF MACHINES
1.1 Rotary Cultivators	2.5	1.03	5	1.20	0.80	1.10	2.7
1.2 Rotary Brush Cutters	3.3	1.10	5	1.20	0.80	1.10	4.6
2.0 Mowers	7.6	1.03	5	1.20	0.90	1.15	9.7
3.0 Patch Scarifiers	12.5	1.06	5	1.20	0.90	1.20	17.2
4.0 Disc Trenchers	13.4	1.03	5	1.20	0.80	1.15	15.2
5.0 Choppers	1.1	1.03	7	1.14	0.80	1.10	1.1
6.0 Plows	18.7	1.03	7	1.14	1.00	1.20	26.3
7.0 Excavators, Patch Scarif.	11.5	1.10	5	1.20	0.80	1.20	14.6
8.0 Blades, Bulldozer or Skidder	175.2	1.10	7	1.14	0.80	1.25	219.7
9.0 Drag Combines	15.9	1.03	5	1.20	1.00	1.40	27.5
TOTALS	261.7					338.6	343

Factors: < 1.00 means fewer machines; e.g. 0.80 means downward adjustment due to double-shifting.

1.00 means no adjustment.

> 1.00 means more machines needed; e.g. 1.03 means increased machines for added lands.

- Item 5.0: Choppers apparently exist in sufficient numbers now to meet projected MSP needs. Renewed emphasis on rehabilitation of stagnated or mistletoe-infested young pine stands might change this. The BCMFL Marden Chopper remained idle for 3 years, but was used again in February, 1987 for that purpose.
- Item 6.0 (plows): Projections call for 27 plows, and about 27 are available.
- Item 7.0 (drags): About 50 drags are available now. Projections call for only 28; the remaining 22 make up an apparent surplus. Drags are relatively cheap to fabricate but costly to transport. Since many Interior operations have draggable cutovers every year, utility of place has more importance for this equipment than the concept of full utilization. Obviously, nothing would be gained by discarding "surplus" drags, and indeed more will probably be designed for special conditions encountered in future.
- Items 8.0 and 9.0 (excavators and bulldozers): These items will be favoured for steeper terrain and on site rehabilitation projects regardless of slope. The major capital cost is in the prime mover in each case; attachments for MSP work are relatively inexpensive. An additional 60 crawlers and 12 excavators are projected for MSP work. These can be drawn from other work when needed, if contract rates are competitive. Special strengthening, guarding, and attachments will be necessary. It will also be important to find experienced MSP operators or to start training good candidates.

In spite of uncertainties in predicting future volumes of work and production rates, an attempt has been made to estimate the numbers of the various types of MSP equipment which must be mobilized for the 1988 field season and for each year thereafter to fulfill the MSP program.

If the attachments (not prime movers) summarized above are purchased new, a rough estimate of their collective cost to various purchasers is:

Rotary cultivators (e.g. Madge)	1	@	\$150 000	-	\$ 150 000
Rotary brushcutter attachments	2	@	8 000	-	16 000
Mounders (e.g. Bracke mounder)	6	@	65 000	-	390 000
Patch scarifiers (selected types)	5	@	50 000	-	250 000
Disc trenchers (selected types)	7	@	50 000	-	350 000
Excavator attachment kits	12	@	15 000	-	180 000
Brush blades, rakes (selected)	60	@	15 000	-	900 000
					<u>\$2 236 000</u>

Prime movers for these attachments will be displaced from other work, and this will lead to additional prime mover purchases. The numbers and types of new prime movers which will be purchased, or the capital which will be spent, are impossible to predict.

Some of the factors which would increase numbers of attachments and prime movers needed are:

- more MSP work than predicted;
- fewer working shifts per machine per year;
- less movement of machines from region to region.

Conversely, some factors which would decrease numbers of attachments and prime movers needed are:

- less MSP work than predicted;
- more working shifts per year (better site or weather conditions, less downtime, double- or triple-shifting, fewer administrative delays);
- improved productivity (better machines and better training of operators).

Two important factors will help determine whether the amount of MSP work actually done is the same, more, or less than the amount predicted. First and most obvious is the question whether it will be possible to bring together all the funds, planning, equipment, administrative streamlining, and on-the-ground determination to commence and complete this ambitious program on schedule.

Second, MSP work must not be considered in isolation from the other site preparation alternatives. Any breakthrough in cost, effectiveness or convenience in one alternative causes more of it to be done, and less of the others. The above projections are not based on the occurrence of any such breakthrough during the period in question. Broadcast burning is already relatively cheap, effective and fast. Improved prescribed-burning technology, favourable weather at the critical times, relaxation of smoke management regulations, economies of scale if openings become larger, and many other factors could shift the balance toward more burning and less MSP. Similarly, herbicide use may increase substantially if technical, economic, and regulatory problems diminish. In site preparation or site rehabilitation applications, however, herbicides will seldom be used alone. Usually they will be accompanied by fire or mechanical disturbance to break down the killed vegetation and expose the soil for conifer restocking.

The concept of achieving site preparation as a byproduct of harvesting has long been cherished. It is certainly true that site preparation can be simpler and cheaper after mechanized felling and full-tree skidding than after manual felling and bucking at the stump. However harvesting and forest renewal are generally still separated, and foresters currently are prescribing some form of independent site preparation on most cutovers and virtually all site rehabilitation projects. Many industry foresters feel that greater integration of harvesting and silviculture would occur on Crown lands if the Cutting Permit and the Section 88 documents were first integrated, rather than kept separate as at present.

3. PROBLEMS WITH PRESENT EQUIPMENT

The effectiveness, production rates, and costs of mechanical site preparation often leave something to be desired. Weather or ground conditions may not be ideal. Machine operators may lack the necessary MSP training or experience. The equipment itself may be inadequate or mismatched to the job, and this is probably the complaint most often heard whether completely true or not. Clearly there are problems with prime movers and implements, and clearly operating conditions in B.C. are not the conditions for which some MSP equipment was designed.

A. Per-Hectare Costs

Mechanical site preparation methods and equipment are judged by their per-hectare costs as well as by their results. Figure A shows the ranges of direct costs for the MSP types previously identified⁷. The cost ranges are grouped for the B.C. Coast (Vancouver and coastal Prince Rupert Forest Regions); the Southern Interior (Kamloops and Nelson Regions); and the Northern Interior (Cariboo, Prince George, and Interior Prince Rupert Regions). Cost ranges for site preparation by broadcast burning, aerial and ground herbicide application, and combined herbicide/burning (brown & burn) are also shown for comparison. A few reported cases of extremely low or high costs per hectare were omitted as atypical. The ranges are considered realistic for costing a series of openings for a year's work.

Obviously the most appropriate treatment is not necessarily the one with the lowest per-hectare cost. The options in Figure A fall into groups according to where they are used, what limits their use, how effective they are, and then what they cost. For example:

Broadcast burning:

Used C, S, N^a

Limited by weather, risk of escapes, smoke complaints.

Effective in heavy debris, on any slope. Mainly helicopter.

Cost/ha C \$300 (70-450); S, N \$200 (20-500). Cost variability is high due to presence or absence of control and mop-up costs (serious escapes are reclassified as wildfires, or upper cost limits would be higher yet). Costs are rising due to more spring and summer burning, requiring more mop-up. When conditions are correct, burning obviously treats large areas faster than MSP. Prompt treatment may ease brush problems.

⁷Sources: cost information collected during visits to FERIC member-company operations and BCMFL districts on another project during 1986.

^aAs in Figure A: C = Coast, S = Southern Interior, N = Northern Interior.

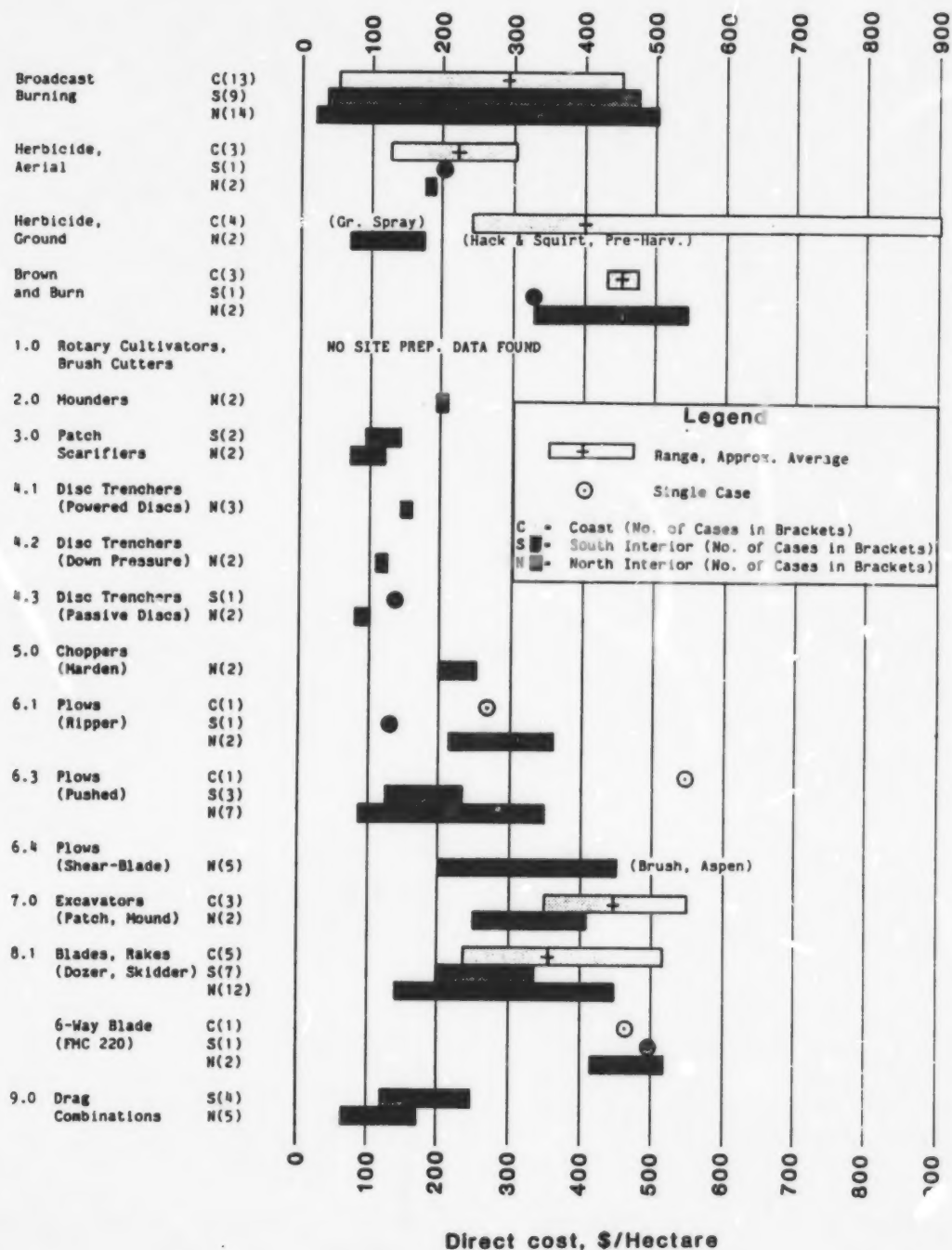


Figure A. Coast/Interior Cost Ranges by MSP Types.

Aerial herbicide applications:

Used C, S, N

Limited by regulation, administrative delays, stream corridors, seasons, weather, target species. Herbicide alone is not normally complete site preparation.

Effective for heavy brush, any terrain.

Cost/ha C, S, N \$120-300. More predictable than burning costs.

Ground herbicide applications:

Broadcast spraying:

Used C, S, N

Advantage: Coverage more precise. Can be used where aerial spray prohibited.

Effective Sensitive areas, back-pack or vehicle-mounted.

(Combination scarification/herbicide treatment shows promise e.g. Bracke Herbicider, App. III)

Cost/ha C \$240-900, (costly in dense brush, small project areas).

Pre-harvest Hack and Squirt:

This technique is used to inhibit aspen encroachment after cutting in the Prince George region. Aspen trees in the stand are manually injected with herbicide.

Cost/ha \$65-170 (Brian Zak, BCFP).

Brown and Burn:

Used C, S, N

Limited by regulations, weather. Not terrain if helicopter used.

Effective on brushed-in (i.e. unburnable) openings. Area should be plantable without further treatment.

Cost/ha \$340-540 (or higher if fire escapes).

Rotary Cultivators:

Insufficient B.C. cost data, but must approach \$1000/ha.

Rotary Brush Cutters:

Insufficient cost data.

Mounders:

Used N only to date

Cost/ha \$190-205 (Bracke Moulder. Higher with excavator.) Bracke mounding costs \$50-100 more than ordinary patch scarification or disc trenching.

Patch Scarifiers, Disc Trenchers (all 3 types):

Used S, N, not C to date.

Limited by Debris, terrain, soils.

Cost/ha S, N \$70-140, 14 sites, wide range of types and models.

Costs for the three types of disc trencher rise as their complexity rises, but only moderately. Within this equipment group, the relatively low cost variation suggests that factors other than cost should govern equipment choices.

Choppers:

Used N only

Cost/ha \$200-250 (flat ground, small pine).

Ripper Plows:

Used C (rarely), S, N

Cost/ha S \$130 (Savona area). C, N \$210-360.

Plows (Pushed):

Used C (rarely), S, N

Cost/ha S, N \$90-360. C \$550.

Shear-blades:

Used N only

Cost/ha \$200-450.

Excavators (Patch Scarify, Mound):

Used C, N to date

Effective Heavy debris, steep or broken ground.

Cost/ha C \$350-550. N \$250-400 (Prince George area).

Blades (Bulldozer, Skidder):

Used C, S, N

Effective Heavy debris, steep or broken ground.

Cost/ha C \$240-520. S \$200-340. N \$140-450.

FMC with Six-way Brush Blade:

Used Steep, wet or sensitive terrain, C, S, N.

Cost/ha \$420-520. Should not be used where crawler or excavator will suffice.

Drag Scarification Combinations:

Used S, N, natural restocking of lodgepole pine.

Cost/ha S \$125-250. N \$70-175 (level terrain, large openings).

Stump Extraction (Root Rot Eradication):

Used C High-site Douglas-fir cutovers. Stumping may increase in Interior.

Cost/ha C \$800-1200.

Stumping will probably be confined to small areas because of high costs. Planting alternative species may often be a better and far cheaper option. For that reason, stumping has been omitted from discussion elsewhere in this report.

B. Operational Problems

The most commonly expressed problems with MSP equipment itself are outlined in this section. These are based on FERIC field observations, widespread discussions with silviculturists, and in the case of north central B.C., on two useful publications (Coates and Haeussler, 1984; Butt, draft 1987).

Equipment types are discussed in the same order as in previous sections, roughly in descending order of mechanical complexity and sophistication.

1.1 Rotary Cultivators

(Have 2 in B.C. Est. 1 more needed by 1988)

The Madge Rotoclear is one example of this type. One machine is located in the Peace River area and one in Burns Lake. They are used chiefly for agricultural land-clearing but have application for rehabilitation of forest lands overgrown with brush. The main problems in forestry appear to be lack of terrain capability, high cost, and danger of "overkill". The Madge consists of a heavy rotor, 225 cm in diameter, powered by a 200-240 kW separate motor, and mounted on a wheeled trailer. Towed by a large crawler tractor, the Madge pulverizes small debris and mixes upper soil horizons in a continuous swath 2.3 m wide. Prompted in part by foresters in B.C., the Alberta manufacturers are considering a similar machine which will cultivate two narrower (1 m) rows for tree-planting. With the prospect of lower power requirements, much less ground disturbance, and better terrain capability, this new design would be of interest in some kinds of backlog site rehabilitation⁹.

1.2 Rotary Brush Cutters

(Have 3 in B.C. Est. 2 more needed by 1988)

In 1982, the Shar 20 brushcutting machine underwent trials doing site rehabilitation work on Vancouver Island. The massive rotating disc was toothed on top, around the circumference, and on the bottom surface. Dense brush and mature alder trees were successfully mulched. The machine was manufactured from the ground up, and unfortunately the prime mover was inadequate for the ground where most site rehabilitation work would occur. The main problem was getting there, not doing the work. There may yet be a successor to the Shar, mounted on a suitable prime mover.

The Hydro-Ax 520 is a standard right-of-way clearing machine, used recently for strip-thinning of juvenile pine stands (Hedin, 1986). It cuts brush and trees as the Shar does, but with articulated hammers instead of a disc. It is unable to cultivate, but will cut and fragment material above the ground. Accompanied by herbicide application or some other form of secondary treatment, the Hydro-Ax might become a more important tool in the reclamation of high-site brushland.

Kootenay Tractor's "Kookutter" is a rugged circular saw, mounted on a boom. This unit, attached to an FMC 220 and driven hydraulically by it, was used to fell and break up alder in preparation for further treatment and planting. The Kookutter is not available commercially.

The problems with this type of equipment are high capital and operating costs, and low productivity. The only solution is to confine it to

⁹A prototype of this new design will be built in 1987.

sites where none of the alternative treatments show promise, and where the benefits of site rehabilitation are substantial. The scope for these machines would probably be reduced even further with the development of herbicides which are effective, accepted, and not subject to red tape and delays of the sort which interfere with herbicide use at present. A combination of herbicide application and one of the other standard site preparation methods, for example, would often be preferred over brushcutter treatment alone in terms of cost, effectiveness, and terrain capability.

2.0 Mounders/Inverters

(Have 4 in B.C. now. Est. need 6 more by 1988)

The principle behind this technique is to provide planting spots with combined mineral and organic soils, elevated position, improved drainage, warmer soil temperatures, and absence of early vegetative competition. McMinn (1983, 1985) has demonstrated the validity of mounding in spruce plantations in the Prince George Region, and there is reason to expect similar benefits with other species and other regions. The Bracke Moulder (see App. III) consists of a two-row Bracke equipped with two hydraulically operated spades, which heap up the soil loosened by the mattock-wheels. It was developed for mounding under Swedish conditions. Three are operating in the Prince George Region with reasonable success.

Problems: Brewis (1984) noted that the mounding spades were "grading off" 65% of the mounds created, by failing to lift high enough at the end of the cycle. This appears to have been corrected. A major problem with this machine on weed-prone sites is the small (40X40 cm) size of the mound and the associated weed-free area (Butt, 1987). The BCMFL Moulder, a recent development of the Forest Service which mounts directly onto a crawler, overcomes this criticism, producing a mound 15-30 cm high, well capped with mineral soil, and better isolated from surrounding vegetation. Neither machine will have the desired effect if the organic horizons are too deep or if the mineral soil is excessively fine-textured. Neither will work well if too much debris or too many stumps remain on the area. The Bracke Moulder is more and more being used for a second-pass treatment, behind brush-blading or burning (Butt, 1987).

Solutions: the exact scope of mounding is probably not yet determined, but it appears to be substantial in the important SBS zone and quite possibly several others. Calculations in the previous section indicate a need for 11 mounders by 1988. Four "solutions" to the problems outlined have promise.

1. The Sinkkila II (i.e. HMF, see App. I) looks like a patch scarifier but is called a scarifier-moulder. It produces acceptable mounds in certain soils (Hedin, 1987) because of its extra-long tines and dragging action. The Sinkkila II has been mechanically unreliable in Alberta and B.C. trials to date, but further modifications and trials should be encouraged because of the promise shown.
2. The BCMFL moulder would occupy an important niche not already occupied by other equipment. Forest Service steps to proceed with

pre-production and production versions (Bedford, Pers. Comm.) should be supported.

3. A moulder attachment for the TTS disc trencher (see 3.0 below) will be on the market soon, subject to resolution of a patent dispute. The combination of disc-trenching and mounding appears different and intriguing.
4. Initial trials at Prince George show promise for use of the small excavator (see 7.0 below) as a moulder. No doubt a specially designed attachment for inverting and mounding would produce better results than the standard rake used in the trials.
5. The concept of the crawler-mounted ripper plow (see 6.0) has probably not been fully explored for site preparation in general nor for mounding in particular. A standard or specialized bulldozer blade on the crawler could part slash. Single or twin rippers behind, with a range of moldboard or wing designs to match conditions, might produce the desired elevating and warming effects of mounding with much less mechanical complexity.

3.0 Patch Scarifiers

(Have 13 in B.C. now. Est. need 5 more by 1988)

Patch scarifiers expose mineral soil in intermittent patches (planting spots) by dragging a cyclically restrained mattock-wheel for the length of the patch and then allowing it to turn until the correct interval to the next planting spot is reached. The planting spots tend to be depressed, unlike the raised spots of the moulder, and this is a limitation of patch scarifiers on sites which drain poorly.

The more common patch scarifiers are described in App. I, III and IV. The Leno and Bracke have been in service in Scandinavia and Canada for well over a decade, while the Sinkkila and Rader/Equisyl 201 are new introductions. Although two-row machines are the most common, one-, three-, four- and five-row machines are offered (Bracke). It is doubtful whether more than 2 rows are practical on B.C. sites, but the increased productivity of a 3-row Bracke justified the added investment on sites in Saskatchewan and Ontario (Ryans, 1985). A Bracke Herbicider is also available and may arouse considerable interest as a way to extend the applicability of the Bracke for one-pass treatment of brush-prone areas.

Problems: The Leno is attached directly to the back of the prime mover (normally a skidder). The mattock-wheels can be raised for backing up or traveling, or lowered for working. The Leno is thus highly manoeuvrable. Nine are working in B.C. Two are Leno 77s (1400 kg) and the rest are Leno 81s, purchased between 1981 and 1984. Neither model is considered capable of penetrating moderate to heavy slash, or compact or rocky soils.

The Bracke is more robust but is mounted on two rubber-tired wheels and towed as a trailer unit. This permits unhitching and winching through difficult ground, but the Bracke is less manoeuvrable than the Leno, and less

stable on sidehills. Although the mattock-wheels can be raised, backing up is awkward.

The Sinkkila HMF is stronger and heavier, with longer tines for deeper penetration, and still should outperform the Leno and Bracke, despite mechanical problems in the initial Canadian trials in 1986. None of the patch scarifiers, however, can be expected to perform in the heavy slash and steep, broken terrain typical of much of B.C.

The width of most European patch scarifiers and mounds is criticized for B.C. applications, where plantation spacings in the order of 2.5 m X 2.5 m are common. The European machines are normally spaced for rows on the order of 1.6 or 1.8 m apart, and are also normally impossible or difficult to adjust. Although the planting interval along rows can be varied to achieve the required number of trees per hectare in a rectangular rather than a square pattern, foresters tend to prefer 2.5 m square over the rectangular extremes of, say, 1.6 X 3.9 m.

Solutions:

1. The Leno 77 and 81 models in B.C. are not fully employed, probably because candidate sites sufficiently free of debris, steep slopes, and rocky soils are hard to find. A contractor in Hazelton has attached a Leno to a crawler with blade for better slash-parting and terrain capability (Bob Johnson, BCMFL, Bulkley F.D., pers. comm.) One trial of a Leno rigged to a highlead steel spar for scarification after yarding on steep slopes was apparently unsuccessful (Brewis, 1981). Except where debris is light, the existing Lenos should probably be regarded as secondary scarifiers, to follow after the debris has been burned, bunched, windrowed, or parted by a front-mounted blade on the prime mover (see Figure B). A new Leno Model 85 apparently exists in Sweden, but has not worked in western Canada.

The Bracke scarifier, used widely in Canada since the early 1970s, is considered more robust. It is still likely that the mechanical problems of the Sinkkila HMF can be overcome. Use of a slash-parting blade on the prime mover (skidder or crawler) would again extend the applicability of these machines into heavier slash.

2. There appears to be no simple solution to the problem of row-to-row width. A separate engineering investigation into the feasibility of increasing width would be needed for each model.
3. Patch scarifiers may find limited application on the coast of B.C. Foresters treating areas on Vancouver Island following mechanized felling and bunching, full-tree skidding, and roadside processing are interested in patch-scarification before planting (Pat Phillips, Cees van Oosten, MacMillan Bloedel, pers. comm.). In many of these cutovers, the slash cover is insufficient for the traditional broadcast burn.

4.0 Disc Trenchers

(Have 9 in B.C. now. Est. need 7 more by 1988)

Disc trenchers, another Scandinavian development, are designed to provide continuous rows of planting spots rather than the intermittent patches of the patch scarifiers. Along with better choices for planting microsites, the scarified rows also tend to provide better foot access for planters.

Disc trenchers evolved from the "passive disc" concept, to the "variable down-pressure", and most recently to the "powered disc" concept. All three are still used productively under differing site conditions.

4.1. Powered Disc Models

Donaren 180D (App. I) This extension of the Donaren 180 (non-powered discs) has twin, hydraulically powered discs, creating two deeply scarified rows of planting spots, suitably spaced. A series of tests of the 180D, mounted on a JD 740 skidder, were run in the Prince George and Cariboo Regions in 1986¹⁰. Contract rates for the series varied from \$150 to \$159 per hectare. At one site visited, in the southeast portion of the 100-Mile Forest District, the 180D created acceptable, well-spaced planting microsites in brush, large felled cottonwoods, soft ground, 20% slopes, and rocky ground.

Problems: Although little or no downtime was experienced in the 1986 trials, more mechanical trouble might be anticipated from the more complex 180D than from simpler trenchers.

According to Gordon Butt (pers. comm.) the 180D discs tend to scatter loosened soil outside the trench rather than retain it as a berm for tree-planting. The discs may be splayed out at too wide an angle for good soil-retention when set for widely spaced rows. This disadvantage was not noticeable in the 100-Mile, Horsefly, or Dawson Creek sites observed, but would be expected most in coarser-textured soils.

Solutions: Different disc angles for different soils would probably prevent the soil losses described, but the 180D has no provision for making the necessary adjustments in the field.

TTS-35 Delta with powered discs. Twenty-two of these powered-head machines are now operating in Canada (pers. comm., Hakmet Ltd.). However, none have been used to date in B.C. The BCMFL and Hakmet expect to arrange major cooperative trials in 1987, covering over 1000 ha in the Cariboo, Kamloops, Prince George, and Prince Rupert Regions. The inter-row spacing for the B.C. test machines will be specially widened to 2.7 m. With substantial down-pressure and powered heads, good performance is expected in heavy soils and slash. The preferred prime mover will be the JD 740, because its mechanical transmission resists overheating better than either hydrostatic or hydrodynamic transmissions, and because ample hydraulic power is available for

¹⁰Donaren leased from Canadian Forestry Equipment, Edmonton; site preparation contracts executed by Arboress Enterprises, Prince George.

the trencher. Other prime movers including crawlers may also be tested.

Problems or solutions: No information for B.C. yet.

Wadell or Markfrasen (conical) scarifiers. This Swedish machine (see App. I) is said to have been patterned to complement the Silva Nova planting machine (Hunt, 1986). Twin scarifying cones, studded to rip the soils and slash, rotate in opposition to the direction of travel. Wadell-type equipment has not been used in B.C., but interest is high¹¹. Hunt (ibid) reports "several big advantages ... good for slash, very adjustable, very good biological results (but) very high tech, complicated machine" ... "Very bright prospects but not ready for Canada for another 2 or 3 years".

4.2 Variable Down-Pressure (Non-Powered Disc) Models:

Examples: TTS-35 Delta, Donaren 180. These are popular machines in planting situations where site conditions are less severe than those requiring powered discs. The discs are free-wheeling. Soil disturbance is caused by the dragging of the teeth, as the angled discs slowly rotate. Hydraulic cylinders permit the operator to force the discs deeper and to penetrate deeper slash and duff layers when required.

Problems: These machines are considered mechanically sound when operated on appropriate sites. They will not penetrate deep or large-diameter slash, and this has been a common limitation in B.C. Competing vegetation may encroach on planting spots rapidly because the root disturbance is less than that produced by powered discs.

Solutions: These machines are mechanically mature and will perform well on appropriate sites. A larger, heavier model mounted on a correspondingly larger prime mover might perform better under the range of B.C. conditions. However, a manufacturer could not interest enough potential users in B.C. alone to proceed, and the standard machines perform adequately in most other parts of North America.

4.3 Passive Models

Examples: CFE trencher (App. I), TTS-35, Rader EQ 402 (App. IV) and EQ 410 (coming). These are the basic disc trenchers, suitable for preparing upland, drier sites with limited slash, shallow duff, and without vigorous competing vegetation. Several TTS-35s are used on pine sites in the Burns Lake area, where natural pine restocking is doubtful and light treatment is needed before planting. The 180 kW skidder and 150 kW crawler are commonly used as prime movers. Houston Forest Products prefers a Cat 528 skidder with a special blade for aligning the slash (visit, Lyle McNabb). Crestbrook Forest Industries has operated a TTS-35 for almost a decade in the MS (montane spruce) zone in the East Kootenays. The terrain in this case is often steep. The prime mover is a soft-tracked FMC 220 skidder (visit, Dave Basaraba).

¹¹Westar at Vanderhoof have recently arranged with the Swedish manufacturer, Storebro, to import a Wadell scarifier for tests in 1987.

Problems: Passive disc trenchers are even more restricted to sites with limited slash and brush risk.

Solutions: When conditions on the site are appropriate for them, passive disc trenchers can be effective and productive (i.e. 1 ha/h). Future applications might include more scarification after broadcast burning to break up unburnt duff for planting. Follow-up disc-trenching might also be a good treatment after herbicide applications, to create planting rows through the dead vegetation. Finally, as in patch-scarification, the range of operability can be increased substantially by using a V-blade-equipped crawler as the prime mover.

5.0 Choppers

(Have 2 in B.C. now. Est. sufficient)

These attachments consist of bladed rollers, single or tandem, drawn passively over the site. The knife-blades chop brush or slash and penetrate up to 27 cm into soft ground. The rollers can be towed straight, angled for greater dragging disturbance, or offset for greater row-width. Rollers range from 1.7 to 2.1 m in diameter and from 2.1 to 3.0 m in length. Total weight (with the rollers filled with oil or water) ranges from 12.2 to 25.4 t. The main application in B.C. has been removal of stagnated or mistletoe-infested pine in preparation for replanting. Frozen ground is preferred.

Examples: Marden Duplex Brush Cutter; Rader Brush Cutter and Cultivator, Models EQ 501, 502, 503 (App. IV); Weyerhaeuser Canada home-built single-drum roller, Okanagan Falls (used for juvenile pine row-spacing, not site preparation).

Problems: The BCMFL Marden Chopper was idle for 2 years, until reactivated for rehabilitation of stagnated pine in February, 1987. Clearly, the double choppers are suited only for smooth, level terrain, since they are unwieldy and the blades would ride over rocks or stumps without touching the ground. Even on ideal sites, soil disturbance is uniform for the entire width of the machine, rather than concentrated in patches or rows to match the desired tree spacing. This draws extra power (150-300 kW crawlers) without producing ideal planting spots.

Solutions: One or two of these specialized machines will be useful for pine site rehabilitation. Their use in rehabilitating brush sites is doubtful, since they would tend only to stimulate most brush species. No design changes or improvements come to mind.

6.0 Plows

(Have about 27 in B.C. now. Est. sufficient)

Forest plows evolved from agricultural patterns, differing only in size and ruggedness. The rock, large stumps, and rough ground common to much of British Columbia's forest terrain make it less attractive for plowing than forest lands elsewhere in Canada, but there are exceptions.

Forest plow designs vary widely. The common B.C. types can be placed in 4 groups:

6.1 Ripper-Type

Ripping breaks up hardpan or compacted soils (e.g. abandoned landings), to provide acceptable microsites for planted seedlings. Dry soils in the IDF (Interior Douglas-fir) zone of the Kamloops and Cariboo regions are ripped in parallel rows to provide slightly depressed microsites where moisture is retained for planted seedlings during drought periods. A crawler-mounted tooth 1.2 m long was used to break up impervious Ortstein subsoil near Gold River on Vancouver Island, with a spectacular improvement in plantation growth (visit, Brian McCutcheon, CIP). Conventional rear-mounted, single or double ripper-teeth used in construction often serve the purpose, but additional "wings" help to mix and break up more soil in the furrow for planting. Specialized forestry rippers such as the Craig-Simpson (C-S), Sanders-Araki, and recently-imported "winged subsoiler" from Oregon make up the nine forestry rippers counted in B.C. (Table 1). The Rader EQ 601 (App. IV) may become an additional choice.

Problems, Solutions: No particular problems are evident, with the possible exception of the potential for landing erosion after careless ripping. Many present-day landings are extensive, and severely compacted after harvesting. Worthwhile work for a population of rippers should be assured in rehabilitation of landings and major skid-trails throughout the Interior. Since the ripper plow follows the prime mover, uncompacted planting sites are assured.

Butt (1987) states that rippers are used on sites where no alternative treatment would work, and recommends optimization of ripper-plow designs specifically for silviculture.

6.2 Drawn Plowshare or Disc Plows

These implements, towed behind a crawler normally, have had relatively little application on B.C. forest lands, with the notable exception of the Peace River area. The Marttiini plow, a massive (3.2 or 4.5 t) design for forestry, has found little application in B.C. Agricultural breaking plows, already active on land-clearing in the Peace River area, are used part-time for forest site preparation. The large, continuous furrow and berm offers a choice of raised or depressed planting spots, free from immediate encroachment by grasses and weeds.

Problems, Solutions: This type of plowing is physically possible on only a small portion of the sites requiring treatment. Even on suitable sites, slow travel speed and the single row would dictate high costs per hectare. On most MSP projects patch scarifiers, mounders, disc trenchers, or excavators will perform similar work at less cost.

6.3 Pushed Scarification Plows (Normally V-Blade)

Fifteen of these C-frame-mount plows were counted for B.C. but there must be more. Many are locally built by the licensee companies or contractors. Commercial models include the Cazes and Heppner (C&H), Beales and Sanders plows, and the Balco moldboard trencher, all built in B.C., and a host of others from elsewhere, including the Muir, CFS (e.g. Rader EQ 301), Fesco, Balderson, and many others. West Fraser Mills designed and built their own model specifically for conditions near Quesnel and Williams Lake.

Problems: V-plowing is considered a drastic treatment, not usually conducive to ideal planting microsites. Plowed strips or patches may be left with only subsoils, may be depressed and susceptible to waterlogging, or may erode on slopes. Concentrations of large stumps make this treatment impossible, although smaller stumps and debris are easily pushed aside without interruption in forward movement.

Solutions: Careful site selection and supervision would prevent most of the undesirable effects. Successful examples of V-plowing are found on deeper soils, and on sites where heavy debris and/or brush would exclude most MSP alternatives. Skilled operators have some success in preventing runoff erosion by alternate raising and lowering of the C-frame while traveling downslope. Perhaps the best application is on highly productive rehabilitation sites, where treatment has been delayed too long (Butt, 1987).

6.4 Shear-Blades (Pushed)

Shearing is an option for achieving a "clearcut situation" before attempting further treatment on sites overgrown with brush (Butt, 1987). Two shear-blades used for forestry are located in the Fort St. John area. The Rader EQ 1001 Shark Plow (App. IV) is commercially available, and features serrated cutting edges and a stinger for stump-splitting. The Beales product is similar, but one-sided (App. V). Shearing practice, which is common in Alberta and the Peace River area, is to skim the ground with an angled or V-shaped blade on front of a powerful (150-250 kW) crawler. When the ground is frozen, brush and trees are brittle and snap off at the ground line, and are windrowed to one or both sides. When the ground is soft, larger shrubs and trees tend to uproot, causing soil disturbance (which may or may not be wanted), while smaller plants bend down and spring up intact behind. Winter shearing is normally preferred, and high production rates are achieved on the frozen ground. This is in no sense a brush-eradication treatment; in fact sprouting will restock the area with renewed vigour unless herbicides or other treatments follow.

Problems, Solutions: Forward visibility is hampered with some shear blades and V-plows. Ground must be almost level, with only scattered large

stumps or boulders. Shearing will clear debris and brush (except for the roots). Other treatments will normally be necessary to inhibit brush regrowth and to create plantable microsites along the sheared rows.

An entirely different application of the shear-blade is considered promising. Rather than plow the soil, it is intended only to align slash away from the path of the prime mover and scarifier. The specially modified skidder blade in Figure B increases the productivity of patch scarification in pine slash. Several other combinations of blade, skidder, and moulder or trencher are under consideration (Hedin, pers. comm.).



Figure B. V-Blade on JD 740 Skidder with Leno Behind (BCMFL Photo, Vanderhoof).

7.0 Excavator-Mounted Patch Scarifiers/Mounders

(Have 3 active in B.C. now. Est. need 12 more by 1988)

The small excavator was first used for mechanical site preparation on Northern Vancouver Island in 1982 (Figure C). The specific task assigned was to scrape the prescribed number of planting spots, and incidentally to provide improved planter access through the debris. Steepness, debris size and density, and terrain sensitivity favoured the small excavator over all other machines, including the bulldozer. The Caterpillar 205 is presently the most popular MSP machine. The preferred implement on the boom is a relatively inexpensive shop-built rake designed to penetrate and mix soil, tear roots, and pinch large debris for removal. On the coast, the treatment is reserved for sites considered unburnable, because excavator patch scarification costs in the order of \$450 per hectare usually exceed broadcast burning costs. Hedin (1986) gives a full description of these coast operations.



Figure C. Cat 205 Excavator with Rake, Northern Vancouver Island.

Excavator patch scarification projects were initiated in the Prince George and Cariboo Regions in 1986, and were considered successful. Moist sites with deep organic soils and debris were mounded at a cost of \$250-400 per hectare (Heather Dawson, Prince George West F.D., Rick Fahlman, Prince George East F.D.). Three contractors with Cat 205s expect to be fully occupied on MSP contracts throughout 1987. At least one is purchasing a second 205 and planning to double-shift both machines, doing MSP and other silviculture work including ground herbicide application and machine spacing.

Major advantages of the small excavator and of the bulldozer (see below) are:

1. The major capital expenditure is made on an extremely versatile prime mover, capable of doing many alternative tasks. Capital expenditure on the MSP implement is minor in comparison.
2. The prime mover is one of hundreds in B.C., fully backed by substantial dealers with parts and repair facilities and people.

Problems: The excavator is inherently slower-moving and costlier than the wheeled skidder, and therefore will never work more cheaply than a skidder on skidder ground. If the site is suited to any of the skidder-drawn equipment, the excavator should not be used. The crawler is like the skidder, but to a lesser extent. This is only a

problem for the excavator contractor if he is unable to find sufficient work for which his machine is best suited. Based on performance to date, excavators appear capable of occupying a series of different special niches in mechanical site preparation. Partly by using its boom and attachment for propulsion as well as for the work, the excavator can move slowly but surely over steep, rough, or soft ground. When the terrain becomes easier, it can speed up. When the terrain becomes easier yet, however, the crawler and then the skidder will start to perform better and more cheaply.

Solutions: The Cat 205 excavator is becoming a proven MSP machine (pers. comm., Jim Fulbrook, owner-operator-contractor). On the other hand the implements for tearing roots, moving chunks, scooping and mounding soil, and other specialized MSP functions could probably be improved substantially once their exact nature is fully analyzed. An MSP excavator boom attachment must have two functions, one to do the required work, and the other to assist in moving and stabilizing the machine.

8.0 Bulldozer/Skidder Blades and Rakes

(Have about 160 in B.C. now. Est. need 61 more by 1988)

Despite the arrival of many new MSP machines in this decade, the crawler equipped with blade or rake accomplished 43% of the MSP done in 1985-86 in B.C. (Table 2). The bulldozer in combination with drags, patch scarifiers, disc trenchers, plows, and other equipment accounted for an additional large percentage of all MSP done. The projections in Table 4 call for 56 438 ha of bunching and blade scarification each year, or 54% of all MSP projected, starting in 1988. Slightly over half of this is in site rehabilitation, where the first task is often to reach a "clearcut situation" by blading and piling unwanted debris and vegetation. The action of crawler tracks and grousers also scarifies the surface and is accentuated by frequent turning. The bulldozer will be hard to replace at this work if the material is dense or the terrain is rough or steep. As an alternative to debris piling, the brush blade is also commonly used to push slash into continuous windrows, and to "rough" compacted landings or skid trails.

Throughout B.C., contractors offer a wide selection of crawler makes, models, shapes, and power ratings. For example, a particular operator with a Fiat-Allis 21C is favoured in the Cranbrook area for debris-bunching and scarification, because of operator experience, mechanical reliability and the 21C's high clearance and good underbody protection (Dave Basaraba, Crestbrook). Elsewhere, the operator-machine choices swing to Caterpillar, International, Case, John Deere, Komatsu, or to FMC for sensitive sites.

Skidders equipped with various rake designs are often used to bunch small-sized slash in Eastern Canada. Because of interest in Interior B.C., the BCMFL will sponsor a 1987 trial of a skidder-mounted rake (Mark Ryans, FERIC; Lorne Bedford, BCMFL).

Along with the variety of prime movers, the choice of commercially sold and home-built blades is wide:

8.1 Toothed Brushblades or Rakes:

The brushblade is used for right-of-way grubbing and land clearing as well as for mechanical site preparation. It differs from the standard blade by having the ability to separate debris from soil. The teeth collect woody debris for piling, and scarify the surface soil but leave it in place.

Examples: The Beales blade (Weldeo-Beales Ltd., Langley, B.C.), available in several forms and sizes, is the most common brush blade used in B.C. (App. V). The standard product consists of a straight blade from which seven rigid teeth 40 cm long project downward (Coates and Haeussler, 1984). Widths from 3.2 to 3.8 m are sold. Rome and Balderson blades of similar design and various sizes are available from Caterpillar dealers. A common modification for deeper soil penetration is to reduce the number of teeth to five, and to lengthen them to 60 cm.

The Eden Rake (Cazes and Heppner, Abbotsford, B.C.) has hinged teeth, controlled by hydraulic cylinders, which will individually pivot back on contact with stumps or boulders, and return to their normal position later. The hydraulic pressure at which the tines are released can be adjusted (Coates and Haeussler, 1984). The Eden rake is designed for mounting on a skidder, and seems more popular elsewhere in Canada, where slash loadings are generally lighter, than in B.C. The German-made Raumfix rake is of similar design and is sold by Canadian Forestry Equipment, Edmonton or Afortek, Thunder Bay, Ont.

Kootenay Tractor, Nelson, B.C. sells a Six-way Blade which mounts on the front of an FMC soft-track carrier, and has been used for bunching and scarification in Coast and Interior applications (Crown Forest, Courtenay, BCMFL, Horsefly F. D.). The blade's articulations and the slope capabilities of the FMC enable contouring on slopes of 35-40% and downhill "dip and dive" scarification on 75-80% slopes (Coates and Haeussler). This equipment is not cost competitive with crawlers on easy ground because of the high owning and operating costs.

Problems: Scarification, piling or windrowing with the crawler and brush blade in heavy debris involves frequent backing and turning as well as forward motion. The cost per hectare is high, but no other equipment can perform better. In lighter debris, however, productivity can be higher with a machine which travels continuously forward, parting slash to either side. This partly explains the use of the angled straight blade or the V-blade for continuous windrowing in areas of lighter slash and uniform ground, as opposed to the brush blade for stop-and-start piling in areas of heavy slash and broken ground.

Solutions: Broadcast burning will reduce debris and some vegetation if fuels are dry and continuous enough. In heavy debris and green vegetation, however, some form of blade treatment may well be the best choice available. On many site rehabilitation projects, piling or windrowing will be necessary before other treatments can begin.

8.2 Straight Factory Blades

The use of the ordinary bulldozer blade was mentioned in connection with winter shearing and windrowing. It is still used on Vancouver Island and is cost-effective on properly chosen sites (Ken Donkersley, CIP). In Northern Alberta, the straight blade is slightly modified by the addition of three 20 cm tabs which project about 10 cm downward from the bottom edge. Cutovers are row-scarified with this modified blade, and aerial-seeded with spruce seed in early spring (Alberta Forest Service visit, Slave Lake). The tabs are presumably to penetrate into mineral soil if the remainder of the blade fails to do so.

9.0 Drag Scarifier Combinations

(Have about 50 in B.C. now. Est. total requirement only 28, but extras useful)

Drag scarification was among the first deliberate MSP treatments introduced in B.C. when commercial clearcutting of lodgepole pine commenced. It is still practiced mainly to secure natural regeneration of lodgepole pine, within the portion of its range where seed is stored in serotinous¹² cones (pine cones are not serotinous in parts of the Prince Rupert Region and pine is restocked from windborne seed or planted there). A range of recycled or home-built materials are used, including marine anchor chain, often with spikes welded across each link, discarded crawler pads set alternatively at right angles to one another for soil penetration, and heavy-gauge steel barrels with "shark fins" welded in spiral patterns. Combinations of 2-5 rows are attached with shackles and swivels to a V-shaped spreader bar or triangular skid boat. Chain alone is used where duff is light. In heavier duff, shark-fin barrels or track pads come first in each row to penetrate the duff, and are followed by lengths of chain to mix the pine cones with the exposed mineral soil. Skidders in the 100-150 kW range are preferred as prime movers because of their speed, but the heavier, multi-row drags require a crawler in the 100-250 kW class. Occasionally, soil and debris conditions permit the use of shark-fin barrels as preparation for planting. (Houston Forest Products has successful pine plantations in the Lakes Forest District established this way.)

Problems: Dragging is cheaper than other MSP methods or even broadcast burning. The new crop will be pine, but pine is almost always the favoured species on the sites dragged. The only problem is control of the stocking of the new stand. Foresters can sample the density and distribution of cones on the ground following skidding, and can then prescribe dragging of appropriate severity, but the stocking is obviously less controlled than that from broadcast burning and planting. On many areas, overstocking can be predicted from cone sampling and soil conditions, and dragging should be avoided on these (Wayne Boudreau, Quest Wood, Quesnel). Failure to predict

¹²Cones open and release seed only after heat melts cone-scale resins.

Sun will open lodgepole pine cones if on the ground, but not if elevated.

correctly will lead to unnecessary spending on both site preparation and subsequent spacing.

As with many of the MSP methods already described, this method is appropriate within a limited range of circumstances and is inappropriate outside that range.

10.0 Other

The "other" MSP machines encountered in this survey are listed at the end of Table 1. Although not nearly so common as the equipment previously discussed, they deserve comment.

10.1 Downing Chain

The Forest Service keeps two of these items but they have not been used in recent years. Apparently, the prospect of transporting the chain, the large-diameter ball designed to keep the chain above the ground, and two powerful crawlers to a site, to say nothing of the potential for entanglements on the site, has discouraged prospective users. The options of manual felling or "walking down" with single bulldozers are common.

10.2 Ripper + "Anchor" Drag

This departure from the conventional dragging equipment was developed through experimentation to improve natural restocking and planting success on drier sites near Savona (Dennis Skjerpen, Evans Products). The equipment is a TD 20 crawler (150 kW), a single ripper tooth, and a short following drag shaped "like a big anchor". The ripper trench, as usual, is designed to retain moisture. The flukes of the "anchor" act to draw soil (and pine cones if any) back into the trench, and also to discourage competing pine grass. In the absence of pine cones, the anchor drag is flipped over and forms a different type of trench for planting. Average productivity on 230 ha treated was 0.7 ha/h. Contract cost was \$130/ha.

10.3 V-Plow Combinations

The "single-pass/double-function" principle could take many forms. A front blade or V-plow would part the debris, while a rear patch-scarifier, moulder, ripper, or trencher would cultivate the exposed soil, rather than ride ineffectively over the debris. The other approach, a "debris" pass followed by a "scarification" pass, is common but may take longer and cost more. Since there are not yet many examples of the 1-pass approach, it is unwise to speculate broadly where it might be more cost effective than separate passes.

4. SOURCES OF NEW EQUIPMENT

Interest in large-scale MSP in B.C. is growing rapidly. Over 150 members of the B.C. forestry community attended a Northern Silviculture Committee (NSC) meeting in Fort St. John in 1986 to observe equipment and treatments in progress. No previous NSC meeting was ever so well attended. The FRDA program is already a massive crash program for site rehabilitation, but also illustrates forcefully the benefits of prompt site preparation on current cutovers in preference to site rehabilitation later. What is the currently available equipment like and where does it come from? Detailed information from five major Canadian suppliers of MSP equipment is reproduced in Appendices I-V. Briefly summarized by supplier:

Canadian Forestry Equipment Ltd./Forest Lease Inc., Edmonton

CFE, located in Eastern Canada as well as Edmonton, has supplied more major MSP equipment to B.C. users than any other supplier (17 pieces, Wally King letter, Jan. 1987). Forest Lease Inc. provides equipment on a rental or lease basis. Thirty-one pieces of MSP equipment, plus a trailer-mount sprayer and 6 fire pump kits are available in the pool (see list of machines and monthly rental rates, App. I).

Equipment types CFE offers for sale, together with approximate 1987 prices, are:

3.0	Patch Scarifiers:	
	Leno Model 85 (apparent update on Model 81)	\$53 000
	Sinkkila HMF	66 000
4.0	Disc trenchers:	
	Donaren 180D (powered discs)	60 000 ¹³
	Donaren 180 (down-pressure, non-powered discs)	47 000
	M.M. Model B-1 2.5 m disc trencher (passive)	36 900
5.0	Choppers:	
	Marden brush chopper B-8GK (CAT D8 size)	61 000
6.0	Plows:	
	C.S. Ripper Plow (CAT D8 size)	5 900
8.0	C.F. Slash Rakes:	
	Raumfix style (sizes #4 to #7)	13 500 - 22 750
10.0	Other:	
	Gallenberg G.K. Forest Sprayer (300 or 500 gal., various options)	12 000 - 20 000

¹³CFE advises (Feb. 17/87) that two Donaren 280D powered-disc trenchers will be available in Canada in 1987. The 280D, unlike the 180D, can be programmed to raise and lower its discs in sequence, creating patches as an alternative to continuous rows.

CFE may also supply the Markfrasen (Wadell) scarifier in the future.

Further information and machine specifications provided by CFE in Edmonton are shown in App. I. Also included is an accompanying letter from Wally King, Edmonton Manager of CFE and President of Forest Lease Inc., outlining his thoughts on MSP equipment.

Except for the Marden Chopper, the G.K. Sprayer, and the fire pump kits, which are North American, every MSP item CFE offers is European in origin. This pattern is similar for Hakmet and KBM.

Hakmet Ltd., Dorion, Que.

Along with an extensive line of equipment (mainly Finnish) for timber-cruising, logging and wood-processing, and seeding, planting and nursery work, Hakmet offers for MSP the full line of TTS disc trenchers, the Marttiini plow, and the Lannen series of ditching machines (App. II). MSP machines applicable to B.C. conditions, and approximate prices fob Dorion are:

4.0 Disc trenchers:

TTS-35 (passive) 2.0 m rows. 1986 price.	\$ 26 500
TTS-35 (passive) 2.4 m rows. 1987, incl. hitch	28 500
TTS-35 Delta (hydr. down-pressure). 1984 price	47 000
TTS-35 Delta with hydr. powered heads, factory-set row-width. 1987 quote	40 000
TTS-35 Delta H (hydr. powered heads, fully adjustable discs). 1987 quote.	70 000
TTS-50 4HJ (four discs, mounted with power-pack on trailer -- prob. not suited for B.C.).	150 000
Prototypes:	
TTS-35 discs, mountable on crawler C-frame. Est.	40 000
Disc trencher with following discs which oscillate for mounding action. In field, no price yet.	-----

6.0 Plows:

Marttiini AKLM 190 (2.5 m width).	approx.	60 000
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Forest Ditching Machines:

Lannen S10 (horiz. reach 6.64 m)	approx.	155 000
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Hakmet Ltd. expect to supply two TTS Deltas with powered heads for use by contractors for the BCMFL and licensees in the Cariboo, Kamloops, Prince George, and Prince Rupert Regions in 1987. This appears to be a serious entry by Hakmet into the MSP equipment field in B.C., and Hakmet may establish a branch office at Prince George.

KBM Forestry Consultants Inc., Thunder Bay

KBM has supplied 4 Bracke (two-row) scarifiers to B.C. users, starting with a BCMFL machine purchased in 1974 and progressing most recently to the purchase of two machines by Integrated Silvicultural Services (ISS) in August, 1986 (see copy of Herb Bax letter, App. III). In addition, two Bracke Mounders from KBM were sold in 1985, one in Fort St. John and one in Prince George. Mr. Bax emphasizes the importance of thorough contractor training on Bracke equipment, and KBM offers regular Bracke training sessions. The KBM site preparation equipment offered, with prices fob Thunder Bay (CFS data bank, Sault St. Marie), is as follows:

2.0	Moulder/invertor/mixers:	
	Bracke 1-row, 1 wheel, non-winchable, 1986 price	\$22 500
	Bracke 1-row, 2 wheels, winchable, 1986	28 900
	Bracke standard 2-row, 1986	37 350
	Bracke Badger, 3-row, 1984 price	52 146
	Bracke Moulder, 1985 price	65 000
	Bracke Herbicide, 1986 price	12 500
	Seeder attachment, 2-row	2 640

Specifications for this equipment are shown in App. III. A letter from Herb Bax of KBM, outlining his concerns about the MSP equipment field, is also included.

Rader Canada Ltd., Montreal

This company was formerly called Equisyl. Rader, a well-known manufacturer of wood-processing equipment in Oregon, have bought Equisyl and will build and market the Equisyl line of MSP equipment in Montreal and Vancouver (see Jean Lavigne letter, App. IV).

Rader/Equisyl site preparation equipment is not known in B.C. The equipment currently offered (new prices not available) is:

- 3.0 Patch scarifiers:
 - EQ-201 patch scarifier
- 4.0 Disc trenchers:
 - EQ-402 mechanical disc trencher
 - EQ-410 "Hercule" disc trencher (drawing stage, Aug./86)
 - Donaren 180D hydraulic disc trencher
- 5.0 Choppers:
 - EQ-501 cutter cultivator, tandem, 2.14 m wide
 - EQ-502 same, 2.44 m
 - EQ-503 same, 3.05 m

6.0 Plows:

- EQ-301 "V" plow (CFS type)
(optional EQ-801 floating frame available)
- EQ-601 Ripper tooth plow
- EQ-1001-5-6-7-8 Shark "V" Plow

The available information on the Rader products listed is shown in App. IV. An updated catalogue and price list should be available soon. If Rader is successful in manufacturing North American alternatives for machines which have been available only in Europe, a major milestone will have been passed. However, there is no way to determine yet whether performance under B.C. conditions will be satisfactory.

British Columbia manufacturers and suppliers

One good way to develop equipment specifically to satisfy local conditions is for the equipment to be manufactured locally, in an atmosphere of continuous interaction between the manufacturer and the local users. Large and small manufacturers all over B.C. could be attracted into MSP equipment development, given the right incentives. The local products should have obvious advantages over products from elsewhere. A few B.C. firms who produce MSP equipment are:

Weldco-Beales Inc. (Beales Steel Products Ltd., Langley, B.C.)

Weldco-Beales produce crawler and excavator attachments of all kinds. New crawlers of several makes are often delivered with Beales blades rather than the standard factory equipment, because Beales blades are known for their ruggedness. The attachments of interest in MSP are shown in App. V, and include:

- 1.0 Rotary brush cutters (excavator attachment):
 - 10-RF (36", 550 lb, 3/8 to 5/8 yd size) \$5400
 - 15-RF, 25-RF (52", 1400 lb, 5/8 to 3/4 yd size) 7700-8100
 - 35-RF (60", 1800 lb, 1-1/4 to 1-5/8 yd) 8700
- 7.0 Other excavator attachments (see drawings and specifications, App. V. Prices not shown available from company):
 - Buckets (e.g. 0.5-1.0 m³ size) 2300-2500
 - Bucket clamps
 - Excavator brush rakes and clearing rakes^{1*}
 - Excavator ripper teeth
 - Lengthened boom or stick (increased reach for spot-scarification)

^{1*}MSP contractors use a simple home-built rake at present, for moving logs, grubbing, scarification, and propulsion.

8.0 Bulldozer (land-clearing) attachments (see drawings and specifications, App. V):

SBB Straight brush blades (e.g. D6-D8 sizes)	\$7000-20000
CBB C-frame brush blades (can be angled)	(similar prices)
One-way brush cutters (i.e. shear blade)	18000-24000
Grapple rakes	(price N/A)
Moldboard rakes (attach to straight blade)	4000-8000
Detachable teeth for straight blade	(price N/A)
Stump splitters	4000
Six-way brush blades	(price N/A)

Weldco-Beales also provide custom modifications, strengthening and guarding packages for prime movers to be used in logging or silviculture. MSP prime movers are likely to need this more and more.

Kootenay Tractor and Supply Co. Ltd., Nelson, B.C.

Kootenay Tractor has been a promoter of the FMC skidder for steep-slope logging and site preparation for a decade. They developed the concept of debris piling and scarification using an FMC skidder equipped with their 6-way blade (\$16 500, fob Nelson). This combination can probably work more effectively on steeper and wetter sites than any other. Although productivity is similar to that of the bulldozer, owning and operating costs are higher. The FMC has been confined chiefly to sites where the cheaper alternatives are unsuccessful.

Cazes and Heppner, Abbotsford, B.C.

This manufacturer, better known as C&H, has supplied the C&H Scarification Plow widely in Canada, but without notable success in B.C. It costs \$16 900 (fob Abbotsford, 1981 price: CFS data bank) The other C&H product, the Eden rake, is similarly used widely, but not in B.C., and the most recent C&H development, a bedding plow, is being built expressly to fill orders from the Southern US. Ironical though it may seem, C&H do not expect significant business supplying the MSP equipment market in B.C. (pers. comm., Lyall Cazes).

H.E. Sanders Ltd., Merritt, B.C.

This family firm uses MSP as a complementary sideline to the main enterprise, construction, land-clearing, and logging. Sanders already owns several crawlers and skidders, and has built several types of V-plows, blades, and ripper plows for use by Sanders on contract MSP in the Kamloops Region. Their equipment and expertise were developed over several years in this region. They are highly regarded by several licensees there.

New Scandanavian Developments

James Hunt, currently studying forestry at the Swedish University of Agricultural Sciences campus at Umea, Sweden, has been commissioned to report on mechanical site preparation in Sweden and Finland: trends, prospects and potential applications in Canada (FRDA Project 1.15 for Silviculture Branch, MOFL, Victoria). His report has not yet been completed, but he submitted a progress report in December, 1986. He summarizes briefly his discussions with silviculturists, machine users, and manufacturers, representing 10 research institutes, 10 forest companies, 2 forest owners associations, and 9 manufacturing companies. He indicates that development of Scandinavian MSP equipment and technology is continuing, especially in the areas of mounding and disc trenching. For example, he describes the new Sinkkila III as a "very promising machine, light, simple, adjustable, inexpensive ---- should try for Canadian licence if possible"¹⁵. He also mentions a "TTS Mounding Delta" without further detail, and is enthusiastic about the prospects for the Wadell scarifier after a further breaking-in period. Conclusions should not be drawn from this progress report, but it suggests that further options for MSP equipment users (and further competition for North American manufacturers) will be forthcoming from Scandinavia.

5. OPPORTUNITIES FOR CANADIAN MANUFACTURERS

Major MSP Equipment

The projections of equipment requirements in Section 1, however liberally interpreted, do not suggest an impending mass market in B.C. for major equipment of the types now used. Herb Bax of KBM puts the Ontario scarifier market into context: 5-6 machines sold per year between 1979 and 1985 (App. III, KBM letter). With similar sales anticipated in Quebec and in British Columbia, Bax projects a total Canadian market of 15-20 scarifiers each year, to be shared amongst several manufacturers.

Evidently neither B.C. alone nor all of Canada would constitute an adequate scarifier market, even for one manufacturer with exclusive rights. A larger market could be created only by development of a machine superior to others over a wide range of field conditions, and priced to attract users throughout Canada and the US at least. Some scope may emerge for Canadian manufacture of selected Scandinavian equipment under licence for the North American MSP market, but the normal difficulties associated with low-volume, high-tech products would be experienced.

The only Canadian manufacturing company apparently in the business of building and selling a full line of MSP equipment is Rader Ltd. in Montreal and Vancouver (see App. IV). Rader appears to be at an early stage with the MSP market, in contrast to its established position in other manufacturing.

¹⁵The concept of a "light" Sinkkila for B.C. is questionable, however successful it may be elsewhere.

Much of the company's work is done through local machine shops in the Montreal and Vancouver areas. This seems an appropriate strategy until demand for Rader equipment makes expansion necessary.

Wally King of Canadian Forestry Equipment and Forest Lease Inc. describes cooperative efforts with Ardco Industries of Texas and Alberta to develop an alternate prime mover for the Donaren '80D (App. I, CFE letter). A decision whether to pursue these efforts further will be made shortly.

Rumours persist that Kootenay Tractor and Supply, of Nelson, B.C., may purchase the Woodlands Division of FMC Corp. and move it from Kentucky to British Columbia. The FMC line of fast-track skidders have gained recognition for their ability to move loads rapidly over steep, rough, soft, or wet terrain without damage to the site. With further technical improvements focused on specific tasks and terrain types and with competitive pricing, this move would give Kootenay an opportunity to enter a world market for a specialized form of transportation. Applications in logging and mining as well as in site preparation, all on difficult terrain, would form a combined market for Kootenay's products.

Cazes and Heppner of Abbotsford designed and manufactured forestry plows and rakes for many years, but have been forced to shift largely to new agriculture/forestry products with a wider field of potential users. The new C&H bedding plow is an example of a switch from a weak Canadian to a stronger American market. No doubt C&H will seek opportunities to re-enter the MSP equipment market in B.C.

Prime Mover Adaptations and Simple Attachments

There are many independent contracting businesses located throughout B.C., who own, operate, and maintain logging and construction prime movers of the kinds used for MSP. Contracting is highly competitive; survival requires reliability and efficiency. It seems evident that these contractors will be successful bidders on much of the MSP work for many years to come, although some work will be done directly by licensees, and some firms will specialize entirely within silviculture, often specializing in some of the more expensive and sophisticated attachments. The more general contractors (i.e. the majority) will purchase the expensive attachments only if they are confident of substantial employment for them. More commonly they will look for some standard form of prime mover and reasonably inexpensive, quickly attached/detached implements, capable of doing the types of MSP which are widespread in the locality. They will strongly prefer prime movers which have other local uses.

Examples suggested from current experience are:

Crawlers with:

- Straight blades (shearing, windrowing, fire-trails);
- Extra-wide tracks for flotation on soft ground;

- Brush blades (site rehabilitation, bunching debris, scarification for planting or seeding);
- Ripper plows (compacted landings, improved microsites, drainage, moisture retention);
- Drag scarifier combinations (heavy drag, multi-row applications requiring crawler power and traction);
- Combinations permitting one-pass debris-parting and scarification (e.g. V-plow in front, drag, ripper, patch-scarifier or disc trencher behind);
- Special machine and operator protection against debris, stumps and saplings.

Skidders with:

- Brush blades (skidders are faster than crawlers in light debris, easy ground; blades of Eden, Raumfix or other type, for piling or aligning slash);
- Drag combinations (again, faster and cheaper in easy going);
- Patch scarifiers or disc trenchers (currently often provided by licensee or BCMFL, contractor provides prime mover and experienced operator);
- Herbicide tanks and ground-spraying equipment (this could be an extension of the familiar tanker-pump-hose unit attached to skidders for fire suppression and mop-up);
- Special machine and operator protection;
- Special axle, wheel, tire, and tire-chain installations.

Excavators with:

- Special MSP buckets;
- MSP rakes (optimized for grasping and piling cull logs and debris, grubbing brush and exposing mineral soil at spaced planting spots);
- Special MSP ripper teeth or stumping attachments;
- Special machine and operator protection against debris, stumps, and saplings;
- Brushcutting, mounding, or other attachments (there may be scope for considerable further research and development in excavator attachments for mechanical site preparation and site rehabilitation).

The most obvious opportunities to serve the MSP equipment market in British Columbia during the 1980s and early 1990s appear to be in the adaptation of factory-built prime movers to meet the special demands of MSP work, and in the fabrication of MSP attachments and implements for them.

Many firms in Western Canada already function exactly in this way, serving equipment users in construction, logging, mining, and agriculture. An extension into the MSP field for them could be a natural diversification rather than a high-risk venture. Their situation is parallel to that of the prospective MSP contractors who are also active in the other heavy-equipment fields. Both groups can benefit from their added capacity to shift easily from one customer to another.

Large manufacturers can utilize their expertise, special tools, facilities, and economies of scale to advantage, and can market whole lines of products. Some of their products will start in one industry and spread to another. Weldco-Beales is a good British Columbia example. Smaller firms can develop equipment for special MSP applications in their localities, based on frequent contacts with the users (or they can even function as developer, manufacturer, and user, as H.E. Sanders does). Large and small firms in B.C. who have already entered the MSP equipment field maintain good communications with the users and forest managers. This has two important implications for the quality of MSP work: steady improvement of the equipment itself, and steady improvement of operator understanding and skills.

CONCLUSIONS

1. The current population of mechanical site preparation machines and implements in British Columbia is estimated at 273 pieces distributed over 10 arbitrary types. Of this total, 160 pieces are brush blades or rakes; 50 are drag scarifier combinations; 27 are plows; and 31 pieces are major site preparation equipment (rotary cultivators, brushcutters, mounds, patch scarifiers, and disc trenchers).
2. An estimated 58 000 ha of "current" MSP and 33 100 ha of "rehabilitation" MSP will be required each year on B.C. Crown lands in the period 1988-92.
3. As a preliminary estimate, 262 machines of selected types could carry out this annual MSP program (Table 4). However, this estimate is based on B.C. Crown lands only, and on ideal utilization of all equipment.
4. After a series of adjustments to cover federal and private lands, necessary machine replacements, expected double-shifting, and extra machines kept as a "convenience" factor, the machine requirements increase to 343 (Table 5).
5. Accordingly, it is estimated that the 273 existing pieces of MSP equipment must be supplemented with 93 new pieces by the 1988 field season. The new equipment needed will consist of 60 brush blades or rakes; 21 pieces of the major equipment group listed above; and 12 MSP attachment kits for excavators. The estimated purchase cost of these new implements and attachments is about \$2.2 million at 1987 prices.
6. Prime movers for the new MSP attachments must also be purchased or diverted from other work. MSP operators with experience or adequate training will be required.

7. The prime movers and the attachments used until now have not always been ideal in terms of treatment effectiveness or per-hectare costs. Some of the problems encountered with current equipment are described and some possible solutions given (Section 3).
8. Some of the MSP equipment available now or becoming available is described in the context of B.C. conditions (Section 4). Several Canadian MSP equipment suppliers and manufacturers are also profiled. Two of these suggest changes to improve MSP in the future (Appendix I and III).
9. Neither British Columbia alone nor Canada alone can form an attractive market for Canadian manufacturers of the major MSP equipment (patch scarifiers, mounds, and disc trenchers) in the 1988-92 projection period. Only one firm in Eastern Canada manufactures a line of this major equipment, and the equipment has not yet been introduced in B.C. This firm or any other would need to capture at least a substantial share of the entire North American market to compete successfully with the established European manufacturers.
10. An individual forest manager can seldom afford to keep all the equipment on hand for all his MSP needs. This accounts for the emergence of an MSP contracting industry. The contractors usually own the prime movers and use them for MSP and other types of work. They may borrow MSP attachments from the BCMFL or licensees as part of the contract terms, lease it from an equipment supplier, or own it outright. By specializing, the contractor can develop local or equipment-oriented expertise.
11. Canadian and B.C. firms can find opportunities in adapting or modifying factory prime movers for MSP roles, and in manufacturing improved MSP attachments for them. Many firms in Western Canada already perform similar roles for equipment users in construction, logging, mining, and agriculture. A diversification into MSP would strengthen some of these firms.
12. Large and small local firms providing MSP modifications and attachments can help improve the quality of MSP work, by maintaining close communications with the equipment users and forest managers. This will ensure improvement in the equipment itself and the understanding and skills of the users.

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APPENDIX I. CANADIAN FORESTRY EQUIPMENT LTD.



Canadian Forestry Equipment Ltd.

17212 - 106 AVENUE, EDMONTON, ALBERTA T5S 1H9

January 26, 1987

Mr. Bob Breadon
F.E.R.I.C. West
Ste. 201, 2112 West Broadway
Vancouver, B.C. V6K 2C8

Dear Bob:

Sorry for the delay in getting this material together for you, however, I hope the enclosed data will assist you in your FRDA project.

The enclosed sales literature gives you some specifications for the various machines that Canadian Forestry Equipment Ltd., handles. Most of these specifications have been handled in detail in the NSC's "A Guide to the Use of Mechanical Site Preparation Equipment in North Central British Columbia"; however, if there are still some information gaps, please let me know and I will endeavor to fill them in.

List prices for 1987 are as follows:

Donaren 180D Hydraulic Power Disc Trencher		\$60,000.00
Donaren 180 Non-Driven Discs Disc Trencher		\$47,000.00
Leno Model 85 Patch Scarifier		\$53,000.00
M.M. Model B-1 2.5M Disc Trencher		\$36,900.00
H.M.F. Moulder/Scarifier (Sinkhila)		\$66,000.00
C.F. Slash Rakes	#4	\$13,500.00
(Raumfix Style)	#5	\$16,750.00
	#6	\$19,900.00
	#7	\$22,750.00



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C.S. Ripper Plow, fits D8K, D8L, D-155	\$ 5,900.00
Marden Brush Choppers B-8GK	\$61,000.00
G.K. Forest Sprayer, 300 and 500 gal.	\$12M to 20,000.00 depending on options.

As for comments concerning selecting and mounting the above mentioned scarifiers on a suitable prime mover, I offer the following:

All towed implements such as the Leno, M.M. Disc Trencher, TTS Disc Trencher, Bracke, Marden Choppers, Drags and Barrels are either pinned to the rear of or pulled on the winch line of a prime mover of the horsepower recommended by the manufacturer of the implement.

However, all prime movers used in silviculture in B.C. have been designed for some other function and borrowed to do site prep work. Historically, the selection process seems to be largely dominated by machine availability in the area, secondly by lowest cost, thirdly by various biases towards one manufacturer or model and finally by some personal perception as to the probability of machine and owner actually getting the job done.

As long as attachments were of the pin on or drag around type the job usually got done, although there was considerable variance in costs and productivity. However, with the newer designs of site preparation machines that do a more specific type of treatment and are hydraulically powered and electronically controlled, the selection of prime mover is much more critical. Furthermore, these units are directly mounted to the frame of the prime mover necessitating considerably more time to mount/dismount, plumb or wire as well as requiring certain heights or angles not considered when the prime mover was designed for an alternate purpose.



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Hydraulic and electrical systems, gear ratios, transmission types, tires and tracks on many prime movers that may be available or offered at a lower bid are simply not suitable for the duty cycle imposed upon them by these new machines and the site prep work they perform. The proper selection of the prime mover has such an influence on the performance of these new attachments that it warrants considerably more research by everyone involved. Many instances of rejection of new technology have taken place because the site prep machine wasn't performing to designed output due to an inferior prime mover.

Specifically, all hydrodynamic transmission (torque converter) systems of 3 or 4 gears usually have too high a gear ratio causing excessive stalling and overheating of the transmission during constant pull applications. This, combined with the heat generated from operating hydraulic attachments causes overload to the cooling system.

Most of the new scarifiers employing hydraulic loading of the scarifying heads were designed to be used with constant pressure load sensing hydraulic systems capable of delivering variable flow as required. Very few available prime movers have this, in fact the only one we have found to date is the John Deere line of skidders. Although I am not trying to promote John Deere products, the JD line also has the only skidders with 8 speed powershift, direct drive (no torque converter) transmissions which offer a good selection of lower gear ratios in a rubber tired prime mover. The JD line of skidders from 80Hp to 175 Hp is possibly the most compatible North American built prime mover for site prep applications.

Mark Ryans at FERIC East has given a good paper (see enclosed) on the deficiencies/desireable characteristics of rubber tired prime movers. Forest Lease Inc., in conjunction with Ardco Industries Ltd., in 1986 undertook to adapt an Ardco 4 x 4 off road vehicle to incorporate some of the desired features for a site prep prime mover. See attached spec sheet Ardco KHSP. We can advise that this unit met with some success but requires further refinement and strengthening to meet the original objectives. This development will be ongoing subject to interest and available funding contracts.

.../4



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With respect to what further equipment development is needed for B.C., I offer the following suggestions:

- development of effective slash parting blades or attachments to clear the path so that towed/mounted trenchers, patch scarifiers, mounds, tillers etc., can do their functions efficiently.
- more operational testing and development of slash piling rakes on rubber tired prime movers to reduce the cost of piling operations (retractable tooth rakes).
- more operational testing/development of cost effective two pass and combined pass treatments on various sites.
- further development of mounds taking advantage of the development work already started with existing machines vs. reinventing the concept.
- development/testing of combined mechanical/chemical treatment equipment.
- cooperative testing and development funding for adapted site preparation machinery technology.
- development, testing of alternate prime movers for silvicultural work, more suited to the duty cycle and ground conditions encountered in site preparation.
- training and development of silvicultural contractors who are trained and properly equipped to do cost effective silvicultural contracting under minimal supervision.
- development of a complete video library on all site preparation machines, their functions, adjustments and proper application on various sites.
- testing and cooperative development of ground based herbicide application machinery, develop costing and application guidelines, when to use this technique vs. aerial application.
- testing and cooperative development of mechanical juvenile spacing/thinning equipment.

Phone (403) 484-8687



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I hope these suggestions and enclosed information offer some assistance and food for thought. I could flesh out further details on most of the above proposals if time permitted or there was a keen interest to fund some work in these areas.

Looking forward to reviewing your report and hearing your comments, I remain,

Yours very truly,
CANADIAN FORESTRY EQUIPMENT LTD.

Wally King
Wally King,
Vice-President



Canadian Forestry Equipment Ltd.

17212 - 106 AVENUE, EDMONTON, ALBERTA T5S 1H9

EQUIPMENT SOLD IN B.C.

- 1979 - Bracke 2 Row Patch Scarifier
B.C.F.S. Kamloops
- Marden B-8GK Drum Chopper
B.C.F.S. Williams Lake
- 1980 - Leno Model 77 Patch Scarifier
B.C.F.S. Kamloops
- 1981 - Leno Model 81 Patch Scarifier
B.C.F.S. Williams Lake
- 1982 - Leno Model 81 Patch Scarifier
B.C.F.S. Smithers
- CFE Disc Trencher Model B-1
B.C.F.S. Kamloops
- Two (2) Leno Model 81 Patch Scarifiers
B.C.F.S. Prince George
- 1983 - M.M. Disc Trencher Model B-1
B.C.F.S. Smithers
- Leno Model 81 Patch Scarifier
B.C.F.S. Smithers
- CFE Disc Trencher Model B-1
B.C.F.S. Prince George
- 1984 - Leno Model 81 Patch Scarifier
B.C.F.S. Kamloops
- Leno Model 81 Patch Scarifier
Babine Forest Products, Burns Lake
- CS Ripper Plow
B.C.F.S. Smithers
- 1985 - MM Disc Trencher Model B-1
Tim Brown, Prince George
- 1986 - MM Disc Trencher Model C-7
Tim Brown, Prince George
- Donaren 180D Power Disc Trencher
Arboress Enterprises Ltd., Prince George



FOREST LEASE INC.

- 17212 - 106 Ave., EDMONTON, Alta. T5S 1H9 (403)-484-6687
- 7355 Torbram Rd., Unit 15, Mississauga, Ont. L4T 3W3 (416)-678-1586
- 90E Brunswick Ave., D.D.O., Montréal, Qué. H9B 2C5 (514)-685-1100

EQUIPMENT LEASING & RENTAL to FOREST MANAGERS & SILVICULTURISTS

FOREST LEASE INC. provides Machinery for intensive management on a RENTAL or LEASE basis.

You can NOW avoid the traditional Capital Costs of purchasing your Site Preparation Machinery. FOREST LEASE INC. has new and well maintained machines available for rent on one to six month rental contracts. It also offers lease contracts for 12 to 24 month periods with various purchase options to suit your needs.

Our selection of Site Preparation Machines available includes:

- DONAREN 180D Disc Trencher
- SINKKILA II Moulder
- LENO Patch Scarifier
- BRACKE Patch Scarifier
- M.M. Disc Trencher
- S.M.35 Disc Trencher
- Slash Piling Rakes (RAUMFIX spring teeth and FORCE hydraulic teeth)
- G.K. Forest Sprayer
- MARK III Fire Pump Kits

we are steadily adding new equipment to meet our customers needs.

DONAREN 180D DISC TRENCHER

New to our list of silviculture machinery. The short, heavy duty DONAREN 180D is a hydraulically driven disc trencher. The DONAREN 180D produces an increased number of good planting and seeding spots. It requires a prime mover with at least 165 HP.

SINKKILA II MOUNDER

Is a silviculture machine new to the North American forestry scene. It has been used extensively and efficiently in Finland for the past few years. The SINKKILA II can effectively create mounds, even in heavy slash loadings. The prime mover required should have approximately 150 HP.

LENO PATCH SCARIFIER

The LENO is a patch scarifier particularly effective on difficult sites (rocky terrain, wet sites and steep slopes, or wherever a skidder can operate). The LENO is a precision machine, hydraulically operated and requires as a prime mover, only a 90 HP skidder.

BRACKE PATCH SCARIFIER

This scarifier is pulled by a 120 HP skidder. It is mechanically operated. Being a larger and heavier machine than the LENO, it is recommended for use of flat areas with few major obstacles.

M.M. DISC TRENCHER

The disc trencher scarifies in continuous rows, consisting of a slight furrow along a slight mound of loose soil. It is pulled by a 140 HP skidder.

S.M.35 DISC TRENCHER

The S.M.35 is very similar to the TTS-35 Disc Trencher 2.0 M. It is also used with a 140 HP skidder.

SLASH PILING RAKES

These rakes are attached to the blade of a skidder and used to both pile slash and scarify at the same time. Their spring loaded (*RAUMFIX*) or hydraulically loaded (*FORCE*) tripping teeth make them extremely efficient site preparation machines.

G.K. FOREST SPRAYER

Is a self contained sprayer designed to permit controlled spraying of herbicides and pesticides on small or large forestry plots. The sprayer unit is mounted on a heavy duty forestry trailer. It is available with the proven *Dickey John D/SC 1000* sprayer control. Other control systems and accessories are also available for this unit. The *G.K. FOREST SPRAYER* is a must for faster, more efficient, professional weed removal.

RENT or LEASE your SITE PREPARATION Equipment from

FOREST LEASE INC.

- * Save scarce capital funds;
- * Increase your tax write-off;
- * Avoid having to spend capital funds to own a piece of equipment which you will only use a few months in the year;
- * We also have good reconditioned equipment for sale or we can offer various lease-purchase options.

Please contact us for further details on these machines, machine brochures, or for scheduling of your season's machinery requirements.

We look forward to serving YOU.

For further details, call:

Wally King at (403) 484-6687, in Edmonton, Alberta.
Jonathan Wynn at (416) 678-1586, in Mississauga, Ontario.
Paul Lamarche at (514) 685-1100, in Montreal, Quebec.

 * FOREST LEASE MACHINE POOL (CURRENT) *

# OF MACHINES =====	TYPE OF MACHINE =====
THREE	DONAREN 180D HYD. POWER DISC. TRENCHER
FIVE	M.M. DISC TRENCHER
SEVEN	TTS/SM DISC TRENCHERS
THREE	LENO PATCH SCARIFIERS
TWO	BRACKE TWO ROW SCARIFIER
TWO	BRACKE BADGER THREE ROW SCARIFIER
FIVE	RAUMFIX RAKES
TWO	CS RIPPER PLOW
ONE	SINKKILA MOUNDER
ONE	GK FOREST SPRAYER
SIX	WJAX FIRE PUMP KITS

WE ARE STEADILY ADDING NEW EQUIPMENT TO MEET OUR CUSTOMER NEEDS.

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1987 LEASE RATES (WESTERN)
 =====

M.P. DISC TRENCHERS	3,200/ MONTH
=====	
T.T.S. / 5M DISC TRENCHER	3,000/ MONTH
=====	
T.T.S. DELTA DISC TRENCHER	P.O.R.
=====	
LENO '81 PATCH SCARIFIER	4,200/ MONTH
=====	
LENO '77 PATCH SCARIFIER	3,600/ MONTH
=====	
BRACE PATCH SCARIFIER	3,800/ MONTH
=====	
BRACE BADGER-3 ROW	P.O.R.
=====	
RAUMFAX SLASH RAKE- FOUR TOOTH	2,000/ MONTH
=====	
RAUMFAX SLASH RAKE- FIVE TOOTH	2,500/ MONTH
=====	
FDOCE HYDRAULIC TOOTH RAKE- C- FRAME MT.	3,500/ MONTH
=====	
SPARKILA HMF MOUNDER	AVAILABLE ON CONTRACT BASIS
=====	
DONAREN 1800 POWER DISC TRENCHER	AVAILABLE ON CONTRACT BASIS
=====	
B.K. FOREST SPRAYER	4,200/ MONTH
=====	
DJSD 1000 RADAR PROG. CONTROLLER	1,000/ MONTH
=====	
GALLIENERS SKID TANK SPRAYER	3,200/ MONTH
=====	
DB RIPPER PLOW-NEW EXTENDED WING MODEL	900/ MONTH
=====	

* OTHER EQUIPMENT AND RATES AVAILABLE UPON REQUEST.

SINKKILA



SPECIFICATION OF THE SINKKILA II
=====

Outer distance of blades (wheels).....600 mm
Width from mid axle to mid axle.....2000 mm
Adjustable depth of bite.....0-600 mm

WEIGHT:

=====

Each wheel system.....approx...1200 kg
Hydraulic system.....approx...800 kg
Total weight.....approx...3200 kg

HYRAULICS:

=====

Oil pressure required by the hydraulic lift maximum 170 bar (2300psi).
Braking hydraulics are self-supporting and do not require tractor's
hydraulics. It is equipped with adjustable safety valve and pressure
gauge.

ELECTRICAL REQUIREMENTS:

=====

Control of braking requires 12 or 24 volts DC.
Controlling unit (100x150x200mm) to be placed into tractor's cap at the
most convenient place.

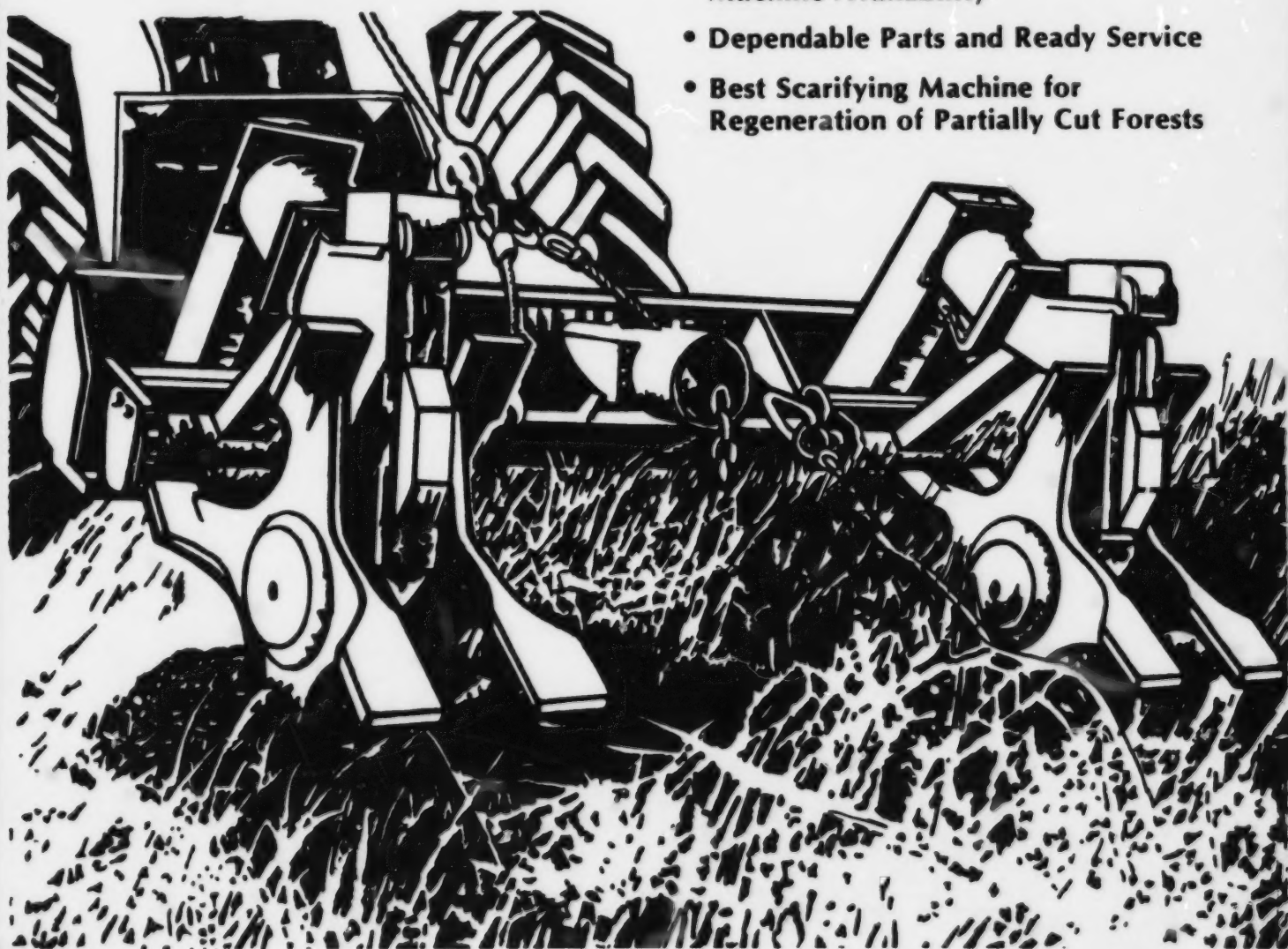
Requirements of tractor (towing machinery):
Necessary motor power.....150 HP.

SINKKILA II IS PATENTED IN FINLAND AND ABROAD #
#####

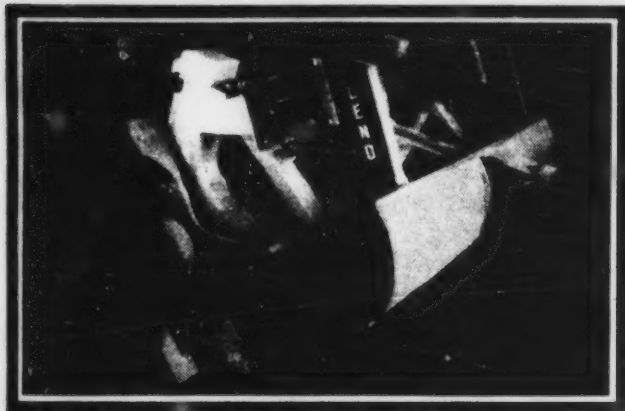
THE NEW LENO '81

PATCH SCARIFIER

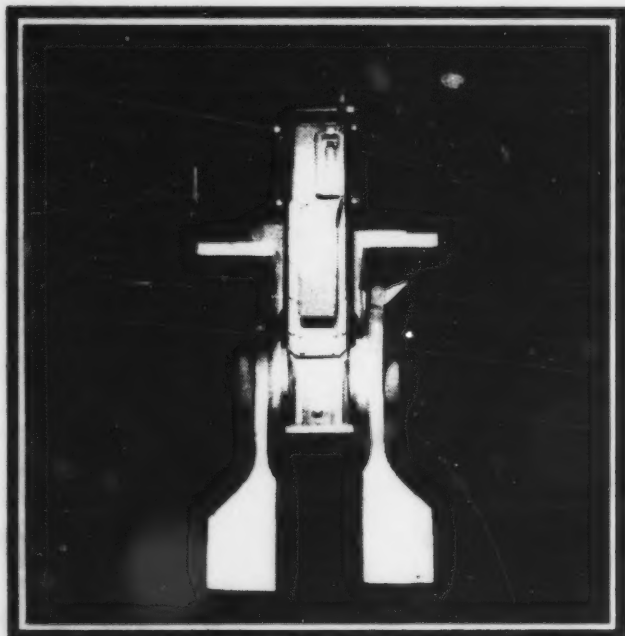
- Requires only a 90 H.P. Tractor, Smallest of any Site Preparation Machine
- Redesigned for North American Conditions
- Precision Hydraulic Adjustments to Vary Size and Spacing of Patches
- Works Efficiently on Steep, Rocky or Wet Sites
- Very Compact and Maneuverable, Convenient for use in Small Scattered Areas
- Minimum Disturbance of the Environment
- Promotes good Tree-Growing Microsites in Arid Conditions
- Low Maintenance and Very High Machine Availability
- Dependable Parts and Ready Service
- Best Scarifying Machine for Regeneration of Partially Cut Forests



THE TOUGH NEW LENO '81...



LENO '81 HAS A NEW STREAMLINED DESIGN



SHORTER HEAVIER AXLES CAN TAKE ON THE TOUGHEST JOB



LENO WORKS ON TERRAIN WITH UP TO A 55% SLOPE

The **LENO '77 SCARIFIER** is well known throughout North America. It has been used profitably on steep slopes, across large flat clearcuts, in small patches, and in combinations of these. Why has it been so successful?

The **LENO '77** is a highly maneuverable scarifier; it has an infinitely adjustable scalp spacer; it works well through relatively heavy slash and around rocks. It can either dramatically reduce planting costs or reduce thinning costs after seeding, by this control which you have on spacing.

However, the **LENO '77** was built to Sweden's specifications and uses. As a result of meetings with the engineers from Canadian Forestry Equipment, a new machine was designed and built with shorter heavier axles, vastly improved suspension and greatly streamlined body components to avoid catching slash. Result? the tough **NEW LENO '81**.

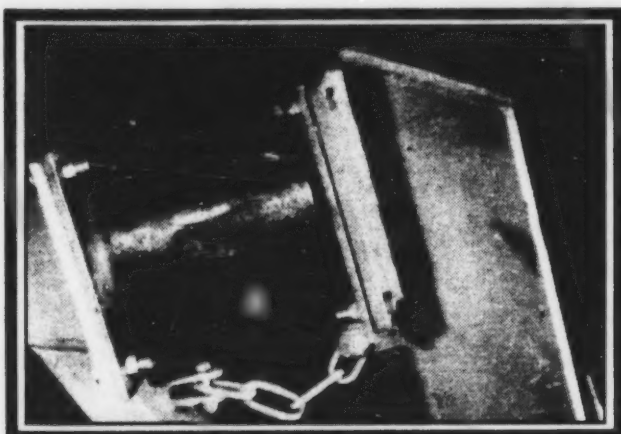
COST EFFECTIVE

Functionally, this machine is the same as its predecessor, but the new design has helped reduce an already very low downtime. The operating speed of the small skidders needed can be increased somewhat, and higher productivity means lower costs.

In Site Preparation work, the highest component of your Cost is the prime mover: The tractor. The **LENO Patch Scarifier** only requires 90 H.P. in tractor power. This is just about the lowest required by any site preparation machine. It is also the lowest hourly cost. Based on an annual production of 2400 acres, and amortizing the machine over 5 years, the operating cost of the **LENO Scarifier** was approximately \$4.80 an acre in 1982; cost of maintenance was approximately \$1.10 an acre.

With the **LENO '81**, you can use any skidder which is handy. You can scarify an **average of 2 acres** an hour on sites covered with slash, rocks, and stumps; **and up to 3 acres** an hour, even on slopes of up to 55%. In fact, it works efficiently on any slope where a skidder can work. It can also be pulled by tracked vehicles on even steeper slopes or broken terrain.

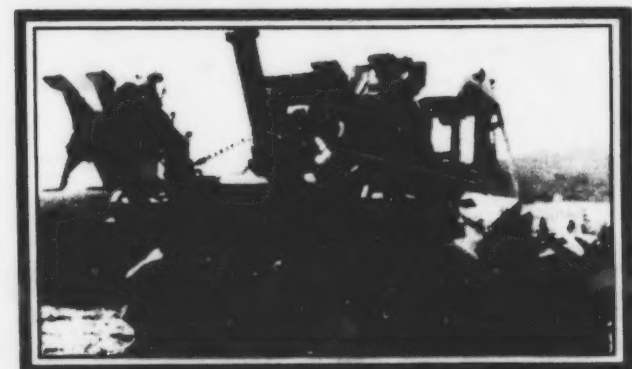
CONSTRUCTION & OPERATION



HEAVIER SUSPENSION REDUCES WEAR



HIGH GRADE SWEDISH STEEL SCARIFYING PADDLES



LENO IS EASILY LIFTED FOR TRANSPORT FROM SITE TO SITE

The **LENO Patch Scarifier** consists of a tube attached to the tractor by a universal joint. A cross-beam carries the two scarifying paddle wheels. The scarifying steel paddles scrape the mineral soil bare.

These wheels are locked hydraulically at the position most suitable for scarification. The tractor operator sets the scarifying time by a simple adjustment. This is the time during which one set of steel paddles scrapes the mineral soil bare. When this preset time interval has lapsed, the paddle wheels automatically unlock and roll about .7 metre (2.3 ft) to the next locked position. This scarifying time can be set, within wide limits, to obtain the desired patch length and also the proper spacing between patches.

An automatic overload release occurs when the paddles hit a stump or rock. They just roll over the obstacle.

Optional bucket type teeth can be used to dig deeper, where deep duff has to be penetrated.

The **LENO Patch Scarifier** can be easily lifted by the tractor winch, which makes it easy to maneuver in tight corners, and to back up.

SPECIFICATIONS

Length: In working position - 2.5 M,
In transport position - 1.0 M

Width: 2.5 M (8 ft.)

Weight: 1600 KG (3500 lbs.)

INTRODUCING THE NEW SINGLE ROW LENO

Our smaller version of the **LENO '81** is designed for use by county forest, farm or woodlot owners. It can be pulled by a farm tractor using a three-point hitch.



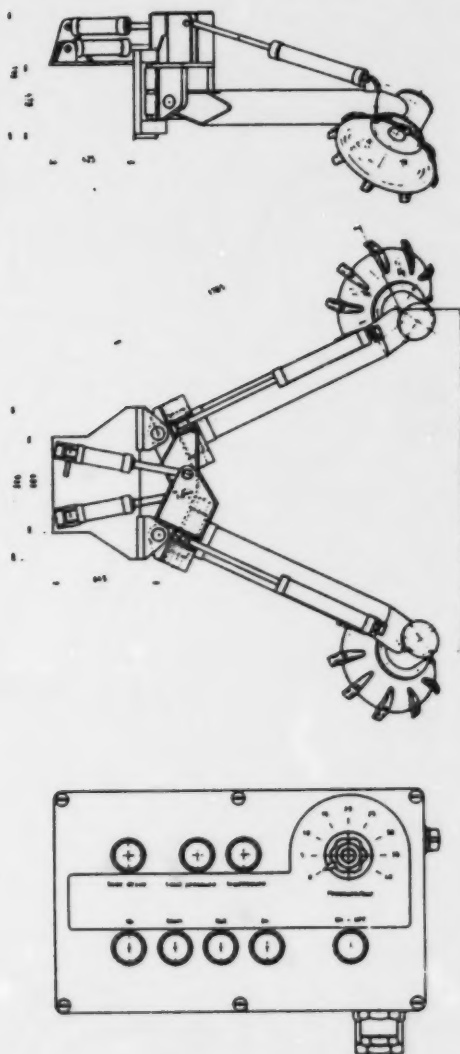
DONAREN 180

The Disc Trencher with Unique Combination Features

The hydraulically driven discs combined with stepless, fully adjustable loading pressure on the arms gives the DONAREN 180 better results on all processable areas.

The short, light-weight DONAREN 180 with these new combination features achieves a higher planting level, an improved working result in logging residue and an increased number of good planting or seeding spots.

The DONAREN 180 with standard equipped arms is prepared for mounting on a hydraulic attachment from which the discs may derive propulsion. From the control panel in the driver's cabin, suitable working positions can be easily selected. The special assembly of the DONAREN 180 to a vehicle not only gives better accessibility to once hard-to-get areas but also better manoeuvrability. The DONAREN 180 can be installed on most makes and models of forest machinery. Spare parts, service and installation can be arranged through the general dealer.



Technical Data:

Measurement:

Discs diameter: without teeth	1050 mm (41.3'')
with teeth	1350 mm (53.1'')
Track spacing	1300—2750 mm (99.0'—108.2'')
Track width	600—800 mm (23.6'—31.5'')
Maximum movement up:	1200 mm (47.2'')
down:	above horizontal position
below horizontal position	1250 mm (49.2'')

Weight:

Gross weight: standard	2300 kgs (5070 lbs.)
driven discs	2800 kgs (6170 lbs.)

Discs:

- Number of replaceable teeth/disc: 10
- Discs and teeth are designed for automatic slash removal.
- Possibility to run the discs opposite way for slash cleaning.

Arms:

The arms have three (3) work positions:

- Work position with stepless loading pressure 0—40 bar (0—580 psi)
- Floating position with 0-pressure.
- Transport position.

The arms and disc bearings are strongly built and are designed to give extensive moveability both upwards and to the side.

Hydraulic System:

Required hydraulic pressure:	Max. 170 bars (2470 psi)
Required flow	85 l/min. (23 gpm)
Variable disc rotation (driven version):	Between 15—30 rpm

Hydraulic motors for the driven discs can be driven in three ways:

- 1 directly from the tractor's pump.
- 2 from a separate pump mounted on the shaft from the power take-off.
- 3 from a separate diesel motor with a pump.

Electrical System:

Current - 24 or 12 V

Electrical control panel conveniently placed in the driver's cab for desired working positions.

Power Requirement:

Engine power required is approximately 90—115 kw.



AB SKOGSBRUKSMASKINER

Box 5, S-783 00 Säter, Sweden
Telephone: 0225/510 80
Telex: 74586 LINDSAW S



**Canadian Forestry
Equipment, Ltd.**

17212 108 Avenue, Edmonton, Alberta T0J 4B4 6667



Canadian Forestry
Equipment, Ltd.

Montreal • Edmonton • Mississauga
(514) 685-1100 (403) 484-6687 (416) 678-1586

THE C.F.E. DISC TRENCHER



The C.F.E. DISC TRENCHER is a simple, sturdily built, and highly versatile Forest Site Preparation machine built in Finland.

It is specially designed to treat poorly drained sites, or those with a high water table. It creates two furrows 1.8 to 2 Metres apart (6 to 6½ ft.), and slight continuous mounds of loose, mineral soil mulched with humus, which are 2 to 2¼ Metres (6½ to 7 ft.) apart.

Any excess water collects in the bottom of the furrow, while the mound offers an excellent micro-site to seed or plant on. The Discs rotate freely and are equipped with spring shock absorbers.

The C.F.E. DISC TRENCHER offers more angular adjustments of the Scarifying Discs than other Disc Trenchers. The width of the furrows can thus be varied from 40 to 100 cm.

The Discs have a larger diameter which enables the C.F.E. DISC TRENCHER to dig into Heavier Duff.

The Disc Teeth are made of Boron Steel, 12 mm. thick, and are profiled. They are more durable than regular Steel Teeth or Bucket Teeth.

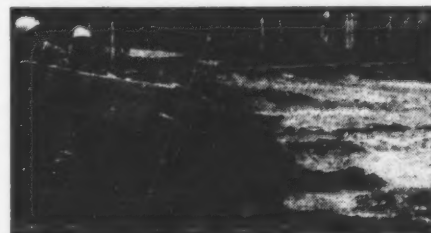
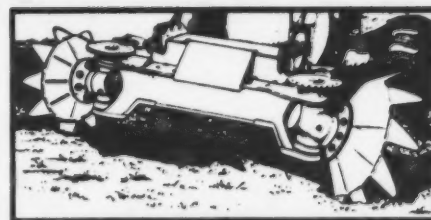
SPECIFICATIONS

Weight: Available in Models from 2 Tons to 3.5 Tons

Required Engine Power of Tractor: 125 H.P. to 170 H.P.
(Depending on Model of Disc Trencher)

Inner Diameter of Discs: 100 cm.

PRICES ON REQUEST



C-S REFORESTATION PLOW

apart. The C-S Reforestation Plow increases planting production and quality.

On low, wet sites, where treatment is impossible in summer, the 36" Ripper tooth can be used in winter once the soil frost is deep enough to support a bulldozer. This leaves a 2-foot to 4-foot wide seed bed to thaw in spring and remain above the high water table which often develops after logging.

This method produces adequate site preparation without creating the mounds of debris and windrows which take much of the area out of production. Debris is broken up and spread out to decompose. Ripper scarification produces a good mixing of soil, whether the soil is wet or dry.

Savings in scarifying cost of \$5 to \$20 per acre can be realized over the use of conventional straight blade.

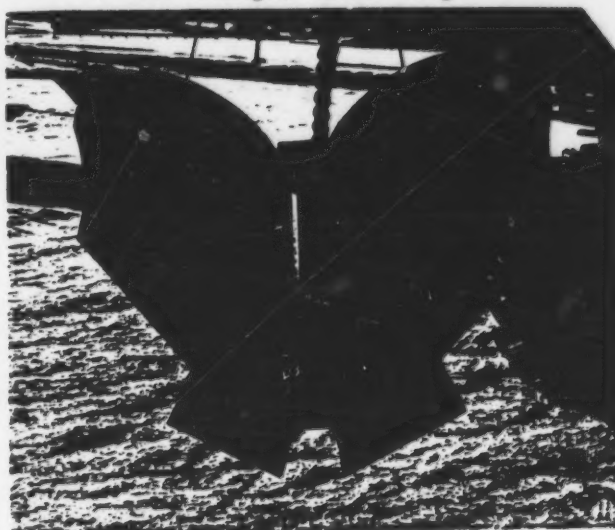
Scarification furrows can easily be interrupted to prevent channelling of run-off, by lifting the tooth clear every 50 ft. to 100 ft., to halt any run-off which could develop, especially on steep slopes. Depth of the seedbed is about 6" to 8".

The subsolling effect of the Ripper Tooth allows available moisture from these lower, poorly drained sites with elevated water table to drain and accumulate below the seed bed. It improves the soil moisture regime by promoting water percolation and increasing available soil moisture.

A seedling, once germinated and starting its height growth, is protected from both drying surface winds and water ponding. First year germination and survival are promoted by the loose mixed soil that retains moisture and promotes root development.

The depth of the trench can be controlled hydraulically by the machine operator.

New Design, Rolled Wings

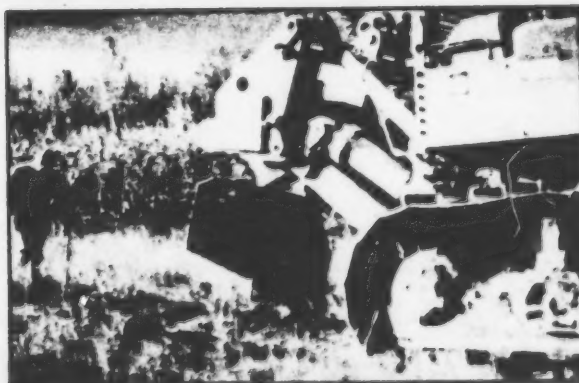
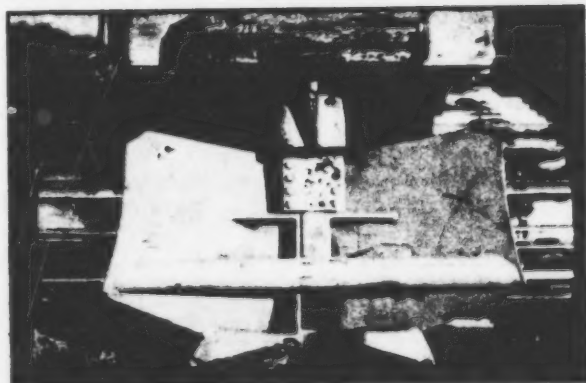


ADVANTAGES OF THE C-S REFORESTATION PLOW

- Scarifies through duff too deep for other equipment.
- Enables site preparation on otherwise inaccessible sites.
- Low investment.
- Simple, sturdy and low on maintenance.

K-189: C-S Reforestation Plow for use with 300HP Tractor

(PRICES ON REQUEST)





FOREST LEASE INC.

- 17212 • 106 Ave., EDMONTON, Alta. T5S 1H9 (403)-484-6687
- 7355 Torbram Rd., Unit 15, Mississauga, Ont. L4T 3W3 (416)-678-1586
- 90E Brunswick Ave., D.D.O., Montréal, Qué. H9B 2C5 (514)-685-1100

räumFix

SLASH RAKE



- * More efficient than any other present day slash rake.
- * Designed with Ergonomics in mind giving the operator a comfortable ride without sudden jerks.
- * Conservation of soil achieved through prongs which follow the contour of the ground.
- * Reduction of fuel due to optimum utilization of skidders pushing force.
- * Repair costs are minimal due to shock reduction design.

Competitive rakes with rigid prongs cause a high impact to both machine and operator when contact is made with a stump. In steering around stumps, 20-40% of production time can be lost. With the competitive rake, poor ground contact often occurs when the machine is in a tilted position.

The design of the RÄUMFIX, with its retractable prongs, allows the rake to follow the contour of the ground without losing the already accumulated slash.

Due to the retractable prongs of the RÄUMFIX, shock loads are reduced. The design of the prongs also enables the operator to remove only the slash during piling operations without excessive soil disturbance.

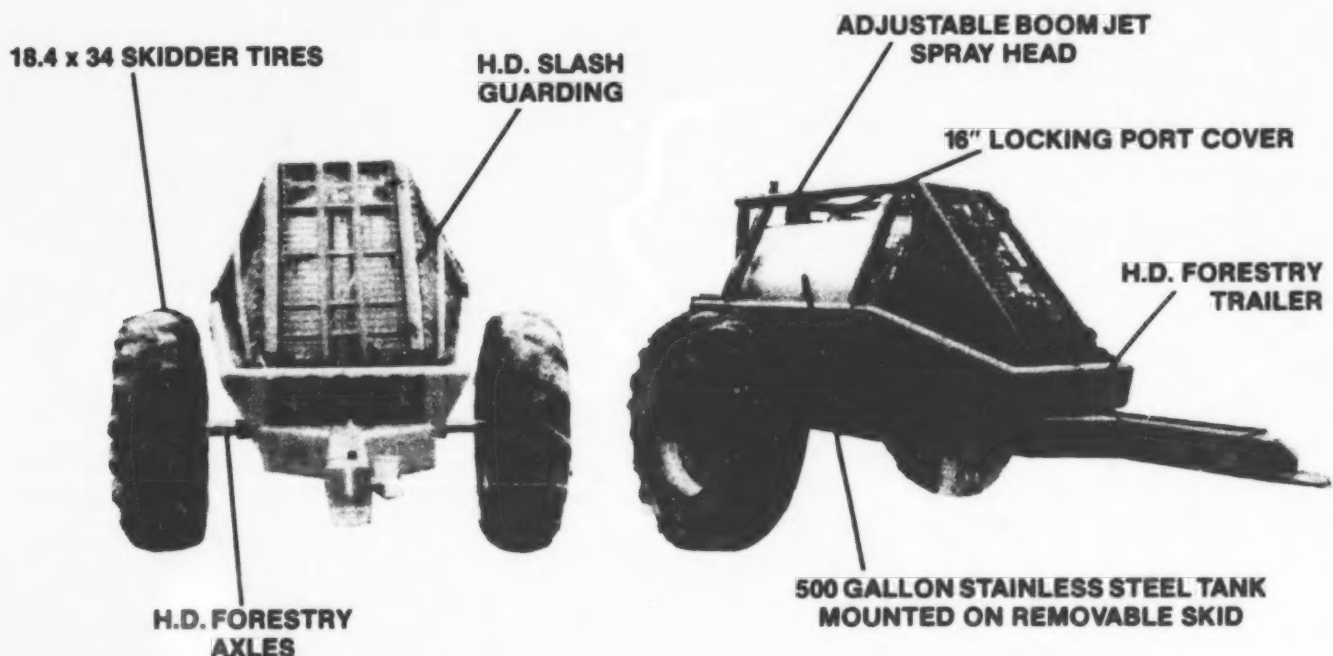
TECHNICAL SPECIFICATIONS

MODEL NO.	TYPE OF PRIME MOVER	H/P REQ.	NO. PRONGS	WORKING WIDTH(mm)	NET WGT(kg)
0	4WD Tractor	50-100	3	1800	350
1	4WD Tractor	60-100	4	2300	470
2	SKIDDER	60-120	4	2300	520
3	SKIDDER	80-120	4	2500	650
4	SKIDDER	100-150	4	2500	850
5	SKIDDER	120-200	5	3000	1250

FOREST LEASE INC.

"YOUR SILVICULTURAL
EQUIPMENT SPECIALIST"

THE G.K. FOREST SPRAYER and FORESTRY TRAILER



Other standard features:

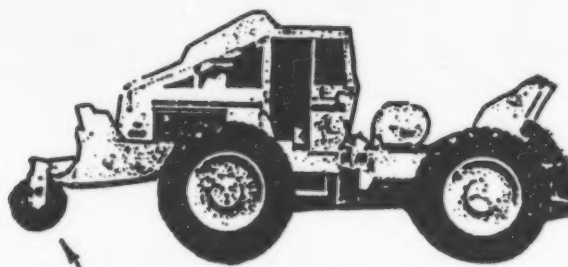
- powered by 8 H.P., 4 cycle gas engine
- two-way internal baffles
- drain valve on the sump
- visual, calibrated fluid capacity gauge
- 12 ga. stainless steel tank
- Hypro centrifugal pump
- sparge tube agitator
- electrical solenoid cutoff switch
- pressure gauge and regulator

Available Dickey John D JSC 1000 Spray Controller:

- programmable controller
- radar ground speed sensor
- pressure flow sensor
- automatically regulates spray rates
- controller console in operators cabin equipped with:
 1. dual shut-off switches
 2. limit alarms
 3. digital readout of forward speed, nozzle pressure, min. & max. travel speeds for pressure limits selected, volume per unit area, and area sprayed.
- available in metric or imperial units.



Canadian Forestry Equipment Ltd.



THE WEED WIPER

N O W : You can apply Herbicide without drip, drift, waste or pollution!

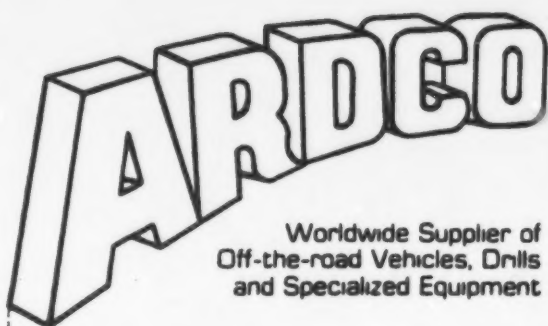
With the **W E E D W I P E R**, you apply the Herbicide only where it belongs: directly onto the weeds.

The **W E E D W I P E R** is mounted on the front of a Skidder or Tractor, and applies Herbicide directly onto the leaves of weeds. This results in the weeds being killed and the tree seedlings beneath being released from competition.

The **W E E D W I P E R** consists of a hydraulically driven high strength roller 10" in diameter and 12' long. A specially designed dibble bar uniformly wets the roller with Herbicide. The chemical is stored in a plastic tank and fed to the dibble bar by a compact 12 volt electric pump. The attachment frame holding the roller assembly is constructed of 2" square tubing.

The advantages of the **W E E D W I P E R** are:

- **NO SPRAY DRIP and WIND DRIFT.** This means that you can apply Herbicides even on windy days
- **NO ATMOSPHERIC POLLUTION**
- **GREAT SAVING IN EXPENSIVE HERBICIDE** because of less waste.
Up to 80% less Herbicide is used compared with spraying.
- **You CONTROL COMPETITION**
- **HERBICIDES SUCH AS ROUNDUP CAN BE USED** with the **W E E D W I P E R**, whereas they cannot be sprayed.

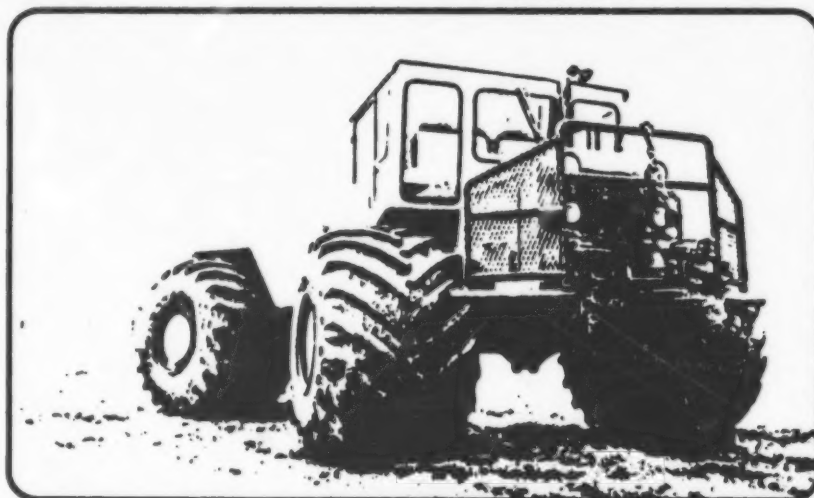


INDUSTRIES LTD.

MODEL "K"

4 X 4

A special model "K-HSP" has been designed to accommodate the special requirements of silvicultural contractors.



The Ardco Model "K" is considered the workhorse of lightweight off-the road vehicles. Its articulated steering and frame oscillation along with low ground pressure terra tires provide maximum moveability in muskeg, sand and Arctic conditions.

Simple design makes the Model "K" easily adaptable for any job. Special equipment may be mounted to suit any application, such as:

Cargo Carriers
Tanks
Drills
Backhoes
Personnel Carriers

Hydraulic Lifts
Snowblades
Gin Poles
Geophone Racks

OPERATING CHARACTERISTICS:

Maximum Speed		25	mph	35 km/h
Turning Radius	- Inside	10	ft.	3,000 mm
	- Outside	18	ft.	5,500 mm
Ground Clearance		22 1/2	in.	572 mm
Vehicle Weight		13,000	lb.	6,000 kg
Payload		10,000	lb.	4,500 kg
Gross Weight		23,000	lb.	10,500 kg

Wadell scarifier shows its capabilities

(AVAILABLE FROM STOREBRO, SWEDEN)

By Danielle Tellier

(CFE may supply in future)



A John Deere 640 turbo skidder and the new Wadell scarifier team up to put on an impressive demo at Abitibi's La Sarre operation.

Last July, the Association Coopérative de Travail de Guyenne took delivery of a Wadell scarifier, the first to be used in Quebec. The Wadell scarifier, which had been integrated to the Swedish Silva Nova planter, now found itself in Abitibi, coupled to a skidder for the first time.

Built by the Swedish firm Storebro Bruks AB, the Wadell scarifier is characterized by the use of two toothed cones which prepare the soil as they turn against the direction of the skidder. The cones are driven by an auxiliary hydraulic motor. An in-cab control panel allows the operator to electronically control the cones' rotation speed, ground pressure and working angle. Depending on the terrain conditions, the operator can then easily modify the profile of the furrows. For example, he may change the scarification process from furrows to lumps when the terrain becomes more difficult.

Conclusive results

Ronald Brizard, Ministry of Energy and Ressources forestry engineer, is supervising this experiment in the

La Sarre area. He considers that "the first results are conclusive." The M.E.R. intends to evaluate the performance of the machine on three different types of soil: loamy, rocky, and covered with logging waste. The tests will be carried out over a three-month period.

During the visit, organized by the Swedish Trade Office on July 24, the Wadell scarifier worked on a loamy, flat and rather clean soil, recently harvested and previously covered with black spruce. "Preparation is more complicated on loamy soil than on any other type of soil," admits Brizard, "because clay does not mix with humus. We want to thin down the humus without lifting the clay. Around here, the layer of humus is generally rather thick."

After only about 50 ha, production was settling at about 0.7 ha per hour. After the breaking-in period, estimates indicate that production could reach 0.9 or one ha per hour, so the machine seems to be capable of doing a good scarification job. However, we must remember that it is still too early to draw any final conclusions, since the terrain was relatively easy and the machine had been in operation for only about 10 days.

The cones are fitted with replaceable teeth. Inside the metal cone, a rubber tire with over 110 psi was installed to absorb shocks and vibration.



The Wadell scarifier is manufactured in Sweden by Storebro Bruks. The Association Coopérative de Travail de Guyenne has one mounted on a John Deere 640 skidder to prepare 350 ha (140 acres) in the La Sarre area.

Owner gets some guarantees

Storebro, the manufacturer, agreed to guarantee, for a certain period of time, to buy back the scarifier (60 percent) if the owner is not satisfied. The M.E.R., for its part, agreed to absorb the amount not covered by this agreement (40 percent). This way, the M.E.R. can analyze the performance of this new machine; Storebro takes advantage of a good showcase for its product; and the Association Coopérative de Travail de Guyenne will only incur the costs of transport, maintenance and manpower, should the experiment prove unsatisfactory.

"So far, everything is going fine," says Antonio Bélanger, general manager of the association. The

The unique shape of the cones allows good penetration

scarifier is covered by a six-month warranty, and two Swedish technicians remained onsite for a month to familiarize Quebec operators with the handling of this machine, which cost close to \$80,000. "We think that we will keep the machine," says Bélanger. "We know that we can carry out the maintenance of the hydraulic system. But we are a little wary about the electronic control system, which is more delicate."

The John Deere skidder

The Wadell scarifier was mounted on a John Deere 640 turbo skidder leased from distributor Machinerie St-Laurent Inc., in Amos. The skidder's winch and grapple were removed, and the scarifier's arms were welded to the frame. This welding was not expected. A

few modifications would probably allow a less permanent mounting in the future.

The skidder has a John Deere motor turning out 120 hp at 2200 rpm, a direct-drive powershift transmission, eight forward speeds and four in reverse, an hydraulic non-slip differential providing a short turning radius, and 30.5 x 32 tires with chains. The 80 hp Fiat auxiliary motor driving the scarifier might not be necessary with a more powerful skidder, such as the John Deere 740, another possibility to be considered. The total weight of the scarifier is 3000 kg.

According to Christer Franzén of Storebro, the unique shape of the cones turning in the opposite direction allows good penetration, without going too deeply, to mix and expose the planting soil. Another characteristic is the presence of a tire inside the base of the metal cone. "This rubber tire," explains Franzén, "absorbs shocks and vibrations, thus reducing the stress on the machine." The manufacturer has determined that the diameter of the cones can reach a maximum of 1.2 m, while the top speed should not exceed 40 to 45 m/min.

The Association Coopérative de Travail de Guyenne plans to scarify 350 ha (140 acres) this season with the Wadell. The Association, with its 35 members, is also preparing 1500 ha (800 acres) in the Senneterre area with two Tree Farmer C-6 skidders with Bracke scarifiers. Another contract, which covers 2100 ha (850 acres), is also underway in the northwest, with two Caterpillar skidders carrying Bracke Monticule scarifiers. This summer, the company is also planting over 2.5 million seedlings provided by Les Serres Coopératives de Guyenne.

APPENDIX II. HAKMET LTD.



Hakmet Ltée/Ltd.

MONTRÉAL: 881, boul. Harwood Blvd.
C.P./P.O. Box 248, Dorion (Québec) J7V 7J5
TEL.: (514) 455-6101 • TELEX: 05-822642
SANS FRAIS-TOLL FREE/ONTARIO, QUÉBEC, MARITIMES:
1-800-361-2288 • TELEFAX: (514) 455-1890

Dorion, Quebec
February 12, 1987

Ref.: 143.

FERIC
201 - 2112 West Broadway
Vancouver, B.C.
V6K 2C8

Attention: Mr. Robert E. Breadon
Research Director

Dear Mr. Breadon,

It was a pleasure to meet you in Vancouver on January 27th and discuss the TTS line of site preparation equipment.

We would like to confirm some points regarding our discussion.

The number of TTS hydraulic trenchers in Canada is 22 machines today. The upcoming season looks very promising, and we expect to have 10-15 more units in operation.

The TTS Delta is designed so that it can be installed on any North American prime mover with the sufficient hp requirement. Regarding skidders, we are talking about 160 hp and in crawler tractors perhaps 150 hp. Major modifications are not required on the prime mover's hydraulic system. In extreme cases, an extra single hydraulic pump may be required. Perhaps the best choice for a prime mover today is John Deere 740 A skidder, which has all the required hydraulic features for the installation.

The first-time installation usually costs between \$2500 and \$5000, depending on the prime mover. The work usually takes 2-3 days for two men.

This year we are looking forward to demonstrating the TTS Delta in British Columbia. We have agreed to do certain changes in the design, so that the requirement of 2.5 - 3 m plant spacing will be fulfilled.

.../2



Hakmet Ltd./L100

-2-

If and when this demonstration takes place, we would be glad to see you participate by carrying out a research study, perhaps similar to the one you did for the standard TTS Delta in Smithers a few years ago.

Should you require any further information, concerning our products or the upcoming demonstration, please feel free to contact us.

Sincerely,

HAKMET LTD.

Erkki Kukkonen
Vice-President

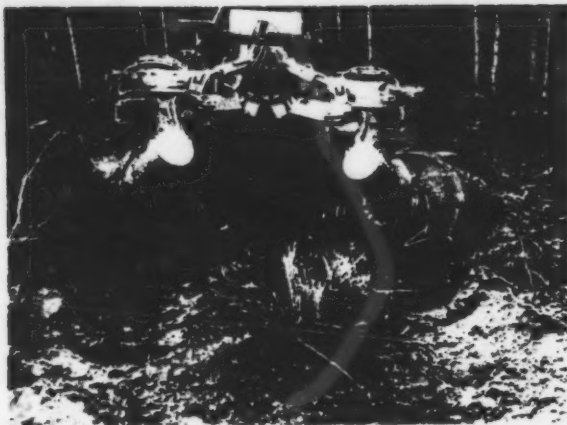
EK/sb

CC: Ms. Ingrid Hedin.



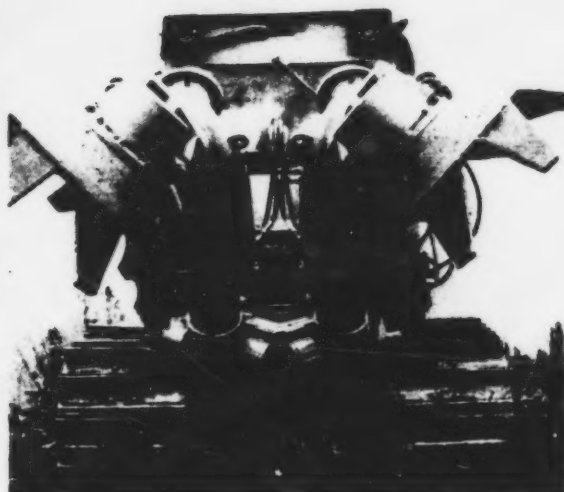
TTS Delta disc trencher

Both discs work independently
Load can be controlled during the operation
Light or heavy preparation as required
Consistent tilling quality
plenty of planting spots

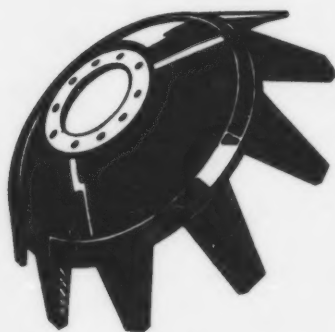


TTS Delta discs can be equipped with a hydraulic motor and a speed reduction gear.

When raised into transport position the TTS DELTA becomes narrower, thus enabling easy and safe transportation on narrow roads. The trencher is raised hydraulically.

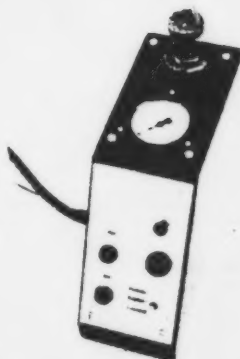


In the picture as a prime mover a crawler.



Canaca discs:

- 1200 mm, 9 teeth, teeth length 270 mm
- 1300 mm, 10 teeth, teeth length 270 mm
- 1400 mm, 8 teeth, teeth length 390 mm



The hydraulic control panel is in the cabin. The operator may adjust the load according to tilling conditions during the operation.



A suitable tractor for the TTS disc trencher is a skidder, forwarder or crawler.

ADVANTAGES OF THE TTS-35 H DELTA

- Automatic hydraulic loading
- Load can be controlled from the cabin during the operation. When the area is difficult to till, the load is increased and where it is easy, the load is decreased or removed.
- The disc arms work independently and follow the variations of the ground.
- A new arm system eliminates peaks in the pulling resistance. The plowing angle is easily adjustable.

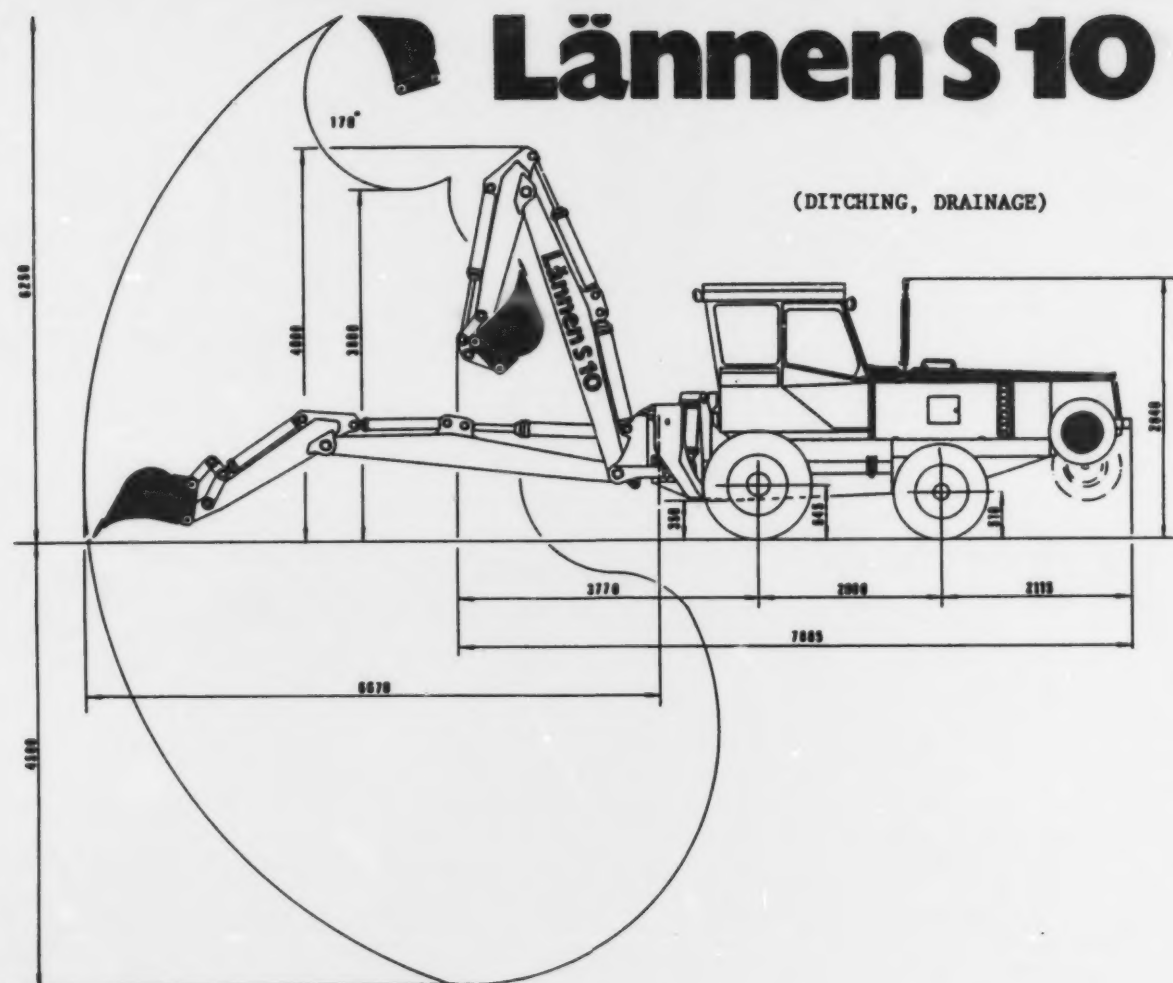
Technical data

Tillers:	2 discs
Distance between furrows:	200 cm standard
Plowing angle:	adjustable in steps of approx. 3°
Width of furrow:	40—100 cm according to disc size and plowing angle
Load of disc arms:	steplessly adjustable
Weight:	approx. 2000 kg
Tractor requirement:	all terrain tractors with pulling capacity of 100—180 kN

TTS-DELTA was developed in the Forest Experimental Station of the Work Efficiency Association (Työtehoseura ry).

TYÖVÄLINE

Karapellontie 12, puh. 00-594 411, Espoo
Postiohje: PL 7, 02811 Espoo 61, FINLAND



Lännen S10

(DITCHING, DRAINAGE)

Lännen S10

- work lights (2 pcs rear)
- rear window wiper and washer
- sunroof
- fender
- hydr. oil cooler
- motor oil cooler
- pneumatic take-off
- electrical power take-off
- 24 V electrics (2 pcs 160 Ah accumulators)
- complete set of tools
- Pares indicator lights
- instruction books and spare parts' book

Technical Data:

Engine	VALMET 411 DS, 4-cyl. water-cooled turbo-diesel flywheel horsepower (95 hp) 70 kW/2300 rpm
Digging hydraulics - double pump	Pressure (3050 psi) 210 bar
Driving hydraulics - adjustable pump	Flow (22 + 17.7 US.gal/min) 83 + 67 l/min// 2000 rpm
Total weight incl. crawler chains	Pressure (6100 psi) 420 bar
Width in transit	Flow (0-37 US.gal/min) 0-140 l/min// 2000 rpm
Width in base	9500 kg
Fuel tank	(8' 1.64") 2.48 m
Tyres	(6' 4.77") 1.95 m
Driving speed	Volume (53 + 50 US.gal.) 200 + 190 l
	Front 16.0-20/PR 10
	Rear 500-22.5/PR 16
	Range I (0-3.2 mph) 0-5 km/h
	Range II (0-16 mph) 0-25 km/h

Digging aggregate performance (SAE J49)

Digging force	(7,190 lbf) 32.0 kN
Breakout force	(15,650 lbf) 69.6 kN
Lifting force	(3,420 lbf) 15.2 kN
Slewing moment	(23,400 lbf ft) 31.7 kNm
Reach	(21' 9.42") 6.64 m
Digging depth	(14' 8.38") 4.48 m
Loading height	(14' 1.29") 4.30 m
Lifting height	(20' 8.03") 6.30 m

All rights for alterations reserved.

APPENDIX III. KBM FORESTRY CONSULTANTS INC.



December 30, 1986

Mr. R. E. Breadon, R.P.F.,
Forest Engineering Research
Institute of Canada
2112 West Broadway
Suite 201
Vancouver, B.C.
V6K 2C8

Dear Bob:

Listed below are my comments on the points raised in your letter dated Dec. 17, 1986. If possible I would appreciate a copy of your report when complete.

- (1) There are over 250+ different types of site preparation equipment available in Canada. (See file at Great Lakes Forests Centre - Mech. of Silviculture Project). From this, I conclude that foresters really don't know what they require. And that the equipment required is site specific (i.e.) what works with one species and site will not necessarily work with the same species on another site.
- (2) The demand for site preparation equipment is like a "fashion show" because no one has defined explicitly what the trees require (with the odd exception, like Dr. McMinns work in B.C.). Since explicit demand specifications are not available, everyone guesses or goes with the current "fashion" or chooses what he "thinks" does the best job.
- (3) Slash removal still constitutes a large portion of the work in site preparation.
- (4) Analysis of the Ontario market from 1979 to 1985 by R. Smith (Great Lakes Forestry Centre) revealed an average of 5-6 new scarifiers were sold per year. If B.C. and Quebec were considered as similar sized markets, then we can project a total demand of 15-20 machines per year across Canada. If a manufacturer had the total market (i.e.) all the machines sold were his, it still would be difficult to manufacture efficiently and economically with such a "low" number.

My argument is that the scarifier market must be looked at on a world wide basis or at least much broader than just Canada. There is insufficient demand for a manufacturer to warrant continuing adaptation and improvement unless he looks at a larger market.

- (5) If the market is being sufficiently serviced by the private sector, the government should not become involved in building scarifiers. Encouragement should be provided by way of purchases of new equipment. (e.g.) If you make the following adaptations to meet our specifications the B.C. government will purchase two scarifiers in 1987.
- (6) With the move to privatization and the use of contractors across Canada and the higher price on scarifiers it may become necessary to move to multi-year contracts so that the contractor has sufficient work to justify the initial capital expenditures.
- (7) To maintain consistent high quality silvicultural standards "stewardship contracts" should be put into place. (See Journal of Forestry, Nov'86). KBM has provided contracts with both site preparation and planting. An increase in cost of \$12.50/ha. in site preparation will realize a \$30.00/ha. decrease in planting, hence an overall lower price of \$17.50/ha. This can only be done when the demand specifications for the trees are clearly identified and matched to the proper scarifier.
- (8) KBM represents a Swedish manufacturer who has expressed a willingness to discuss manufacture in the West. Several letters have been written, asking for commitments for further discussion - to date, we have received no replies. I have assumed the government is either not willing nor serious or simply have insufficient data to make a firm commitment.

ITEM 1 Scarifiers

Bracke Two Row

1974	S/N	50081	DNR	Prince George, B.C.
1979	S/N	50262	DNR	Kamloops, B.C.

Bracke Moulder

1985	S/N	60371		Gellings Enterprises #20, RR#1, Fort St. John, B.C.
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Bracke Moulder

1985	S/N	60392	ISS	Integrated Silv. Service 4185 15th Ave. Prince George, B.C., V2M 1V8
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Bracke Two Row

	S/N	50393	ISS	Aug. 1986
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Bracke Two Row

	S/N	50394	ISS	Aug. 1986
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Item 1 (cont'd)

page 3

Comments

Equipment demand should rise significantly in view of B.C.'s programs for current and backlog forest renewal. Specifically we would see a need for Bracke Mounders, Bracke Herbicides and some Bracke Two Rows.

The problem will be to provide the necessary training to the perspective future contractors. Our experience has shown that unless the contractor participates in a KBM Bracke training seminar, the equipment is used incorrectly and the results are less than satisfactory.

DELETED - PERSONAL

Bob, I hope these thoughts are of some help. Appreciate the opportunity for input.

Yours truly,

A handwritten signature in dark ink, appearing to read 'Herb Bax', is written over a faint, circular stamp or watermark.

Herb Bax, R.P.F.,
Manager

HB/mat



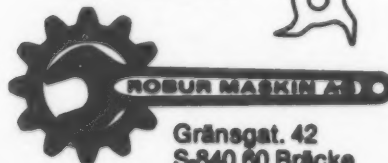
General particulars

Weight	3 000 kg
Length	approx. 5 m
Width	2.53 m
Ground clearance	approx. 0.8 m
Centre-to-centre spacing between patches, laterally	2.0 m
Centre-to-centre spacing between patches, longitudinally	2.2 m

Agent



**BRÄCKE
SCARIFIER**
manufactured by



Grängsät. 42
S-840 60 Bräcke
Sweden
Telephone: (0693) 101 09



360 MOONEY STREET
THUNDER BAY, ONT.
P7B 5R4
PH: (807) 344-0811
TELEX: 073-4603

TABLE 1. Bracke Modifications and Resulting Uses

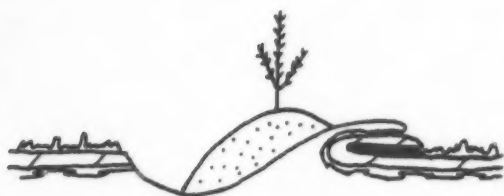
<u>Bracke Modification</u>	<u>Result</u>	<u>Use</u>
Change from a four tooth mattock wheel to a five tooth mattock wheel.	Increases the number of patches per hectare. Creates smaller patches and almost a continuous patch row.	To increase stocking. To improve conditions for manual planting, where slash buildup between patches is a problem.
Change to a new style mattocks, with replaceable teeth. (Standard on all 1982 + models)	Improves slash and soil penetration. Reduces downtime in the field.	In heavier slash accumulations and deeper duff, provides better results.
Change intermediate axle gear (15 tooth - 17 tooth - 19 tooth)	As you reduce the number of teeth in the gear you reduce the turning speed of the mattock wheels thereby decreasing the number of patches per hectare. Increase the size of individual patches.	Where larger patches are required (eg.) for competition. Increase Mineral Soil Exposure and duff disturbance. Reduce stocking.
Load tires with salt water.	Reduces "spinning and slipping of tires" thereby increases number of patches.	In combination with other recommendations where heavy slash is present.
Use grip-type tread pattern on tires.	As above.	As above.
Widen tip of the mattock wheel.	Increases width of scalp. Reduces length and depth.	Use only in light duff areas.

BRÄCKE MOUNDER

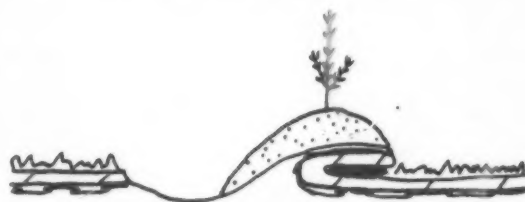


Schematics of Microsites Created

"Mineral Mound"



"Humus Mound"



BRÄCKE MOUNDER

Manufactured by



ROBUR MASKIN AB

S 840 60 BRÄCKE
SWEDEN
Telephone 0693/101 09

NORTH AMERICAN
DISTRIBUTOR

k b m

THE CONSULTANTS INC.

900 Midway Road
Suite 100, Elmhurst
Ill. 60120-1441
Telephone 800-744-1011
Fax 708-581-2000

Bräcke Moulder — Superior microsites for growth

Many years mounding with the Bräcke Moulder, has proven that pine and spruce seedlings exhibit better growth on mounds, especially on sites with high water tables and where temperature is a limiting factor. The benefits of mounding have been well documented and include:

- Greater soil temperatures which benefit root growth and establishment.
- An elevated well drained microsite.
- Highly aerated and porous soil with high moisture retention characteristics.
- The elevated microsite gives greater freedom from competition and minimal risk of smothering or drowning.
- Clean soil is less prone to invasion from dormant weed seeds within the growing medium.
- Improved nutrient availability from the rapid breakdown of trapped litter and humus layers.
- Little damage to the forest ground benefits longterm growth and stem stability.

SPECIFICATIONS:

Engine:

Deutz — air cooled
Model/cylinders
Max hp
Fuel tank capacity
Fuel consumption

FL 511/2 cyl
26 hp (19.5 Kw)
20 litres (4.4 gal/imp.)
2—3 litres/hour
(.4—-.7 gal/hour)

General particulars:

Weight	4500 kilos (9,920 lbs)
Length	5.85 metres (18.3 ft.)
Width	2.53 metres (8.3 ft.)
Ground clearance	0.80 metres (2.6 ft.)

Prime Mover

: 120 - 140 HP skidder or crawler of similar power

Ground Speed

: 30 - 60 meters/minute

Ha/Hr

: .7 - 1.8 average 1.2

Application

: The Bräcke Mounding Scarifier is particularly suited to sites where soil temperature is a limiting factor for establishment and growth. The advantages of mounding are also applicable to over moist mineral soil where microsite drainage is required and on infertile sites where retention of humic material is critical. Elevation of the plant above ground competition is also obtained by mounding. The mounding scarifier can also be used for regular Bräcke scarification.

BRÄCKE HERBICIDER

SUPERIOR RESULTS THROUGH CONTROLLED APPLICATION AND ACCURATE PLACEMENT

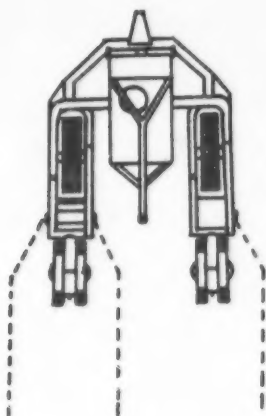
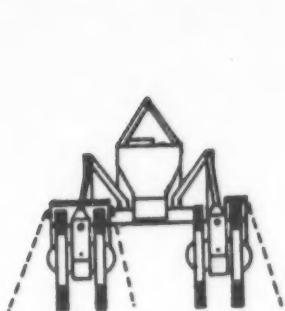


- Application at the time of site preparation will increase chemical effectiveness and reduce crop damage
- Accurate placement reduces off-target drift
- More environmentally sensitive areas can be treated
- A smaller amount of the total site can be treated with superior results
- Specific weed problems can be treated more effectively
- Application costs are reduced through combination of treatments
- Three spray systems allow for flexibility in site prescription

FEATURES

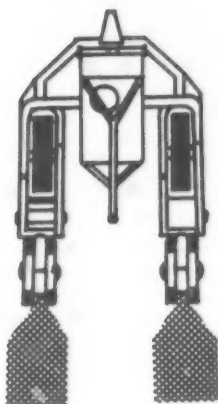
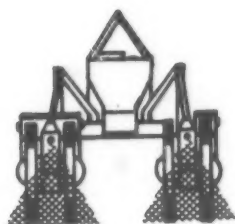
- 2 cylinder piston/diaphragm pump
- 3 types of application systems
- Individual nozzle control
- Automatic application rate adjusting
- Standardized North American components
- Stainless steel tank construction
- Canadian developed designed and tested

NOZZLE POSITIONS



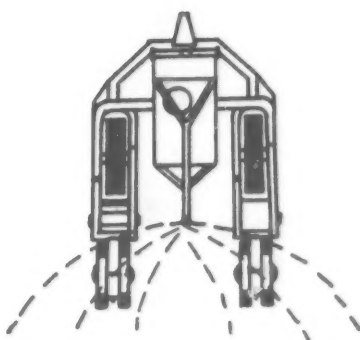
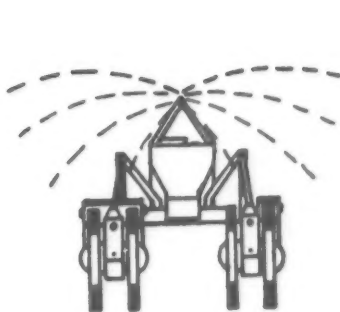
SIDE NOZZLE

Machine frame mounted for use with soil active foliar and basal bark sprays.



REAR NOZZLE

Alone or in combination to treat the patch row with soil active herbicides.



BOOM MOUNTED

For use with foliar active herbicides using very low pressures and volumes up to 350 l. per ha.

The Bräcke Herbicider is jointly manufactured by Robur Maskin AB in Bräcke, Sweden and by KBM Forestry Consultants Inc. in Thunder Bay, Ontario, Canada.

The manufacturer reserves the right to make changes or add improvements at any time and without incurring an obligation to make such changes on machines previously manufactured.

APPENDIX IV. RADER CANADA LTD.

Rader Canada Ltée/Ltd.



RADER

C.P./P.O. Box 925
Saint-Laurent, Québec
H4L 4W3
Téléphone (514) 331-1200
Telex: 05-824609
FAX: (514) 331-7754

Montreal, 31 December, 1986

Mr. R.E. Breadon
FERIC, Western Division
2112 West Broadway, Suite 201
Vancouver, B.C.
J6K Z6P

Dear Mr. Breadon:

Please find enclosed our 1986 catalogue on site preparation equipment.

We are presently through the winter months, revising all our equipment to stay ahead of the competition and to assure our clients the best machinery for their purpose. We will release our new catalogue early this spring which will include our new models and the new features on the already existing machinery. In fact, our prices will be lower on some of our equipment due to better design and simpler assembly.

By the time this catalogue will be available, we should be organized to assure customer service in Western Canada using our Vancouver office.

Yours truly,

RADER CANADA LTEE/LTD.

Jean Lavigne
Consultant
Forestry & Silviculture

JL/mv

Encl.

Rader Canada Ltée/Ltd.



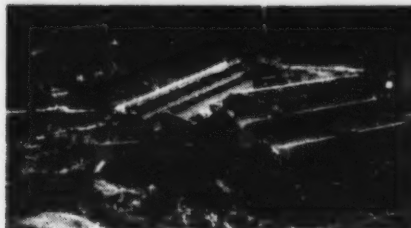
RADER

C.P./P.O. Box 925
Saint-Laurent, Québec
H6L 4W3
Telephone (514) 331-1200
Telex: 95-824609

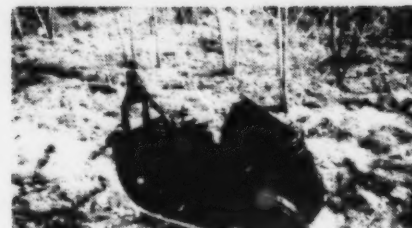
SYLVICULTURAL EQUIPMENT SPECIALISTS RADER CANADA LTD.



**PATCH SPACING SCARIFIER
EQ-201**



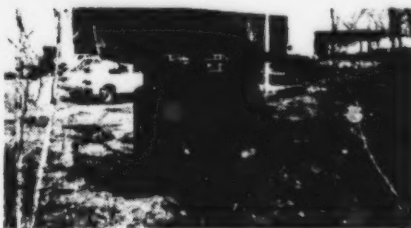
**BRUSH CUTTER CULTIVATOR
EQ-501-502-503**



**MECHANICAL TREE PLANTER EQ-1201
3 POINT HITCH ATTACHMENT**



**"V" PLOW (C.F.S.)
EQ-301**



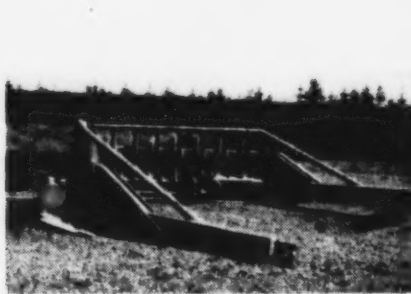
**"V" PLOW (C.F.S.) EQ-301
(REAR VIEW)**



**RIPPER TOOTH PLOW
EQ-601**



**MECHANICAL DISC TRENCHER
EQ-402**



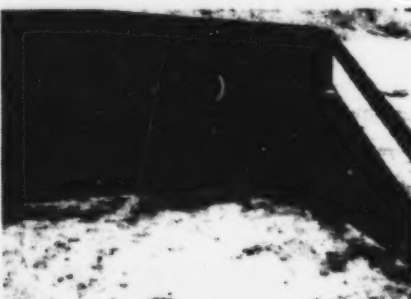
**SHARK PLOW "V"
EQ-1001-5-6-7-8**



**HYDRAULIC DISC TRENCHER
(DONAREN 180D)**



**MECHANICAL DISC TRENCHER EQ-402
(QUICK-DISCONNECT TYPE)**

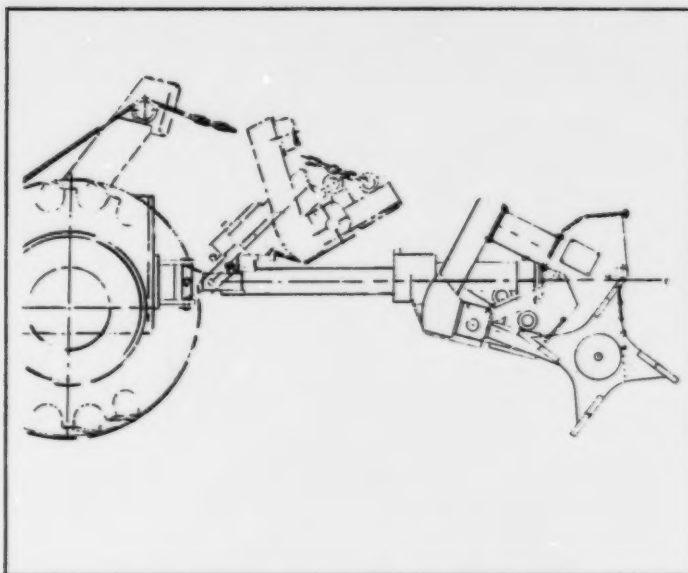


**SHARK "V" PLOW EQ-1001-5-6-7-8
(REAR VIEW)**



**HYDRAULIC DISC TRENCHER
(DONAREN 180D)
(TRANSPORT POSITION)**

Rader Patch Scarifier



SPECIFICATIONS:

<i>Description</i>	<i>English</i>	<i>Metric</i>
Extended length (operating mode)	10'-3"	3124 mm
Retracted length (transport mode)	5'-8"	1727 mm
Overall width	7'-11"	2413 mm
Overall height	4'-8"	1422 mm
Center to center of mattock wheels	5'-10"	1778 mm
Width of mattock wheel	1'-7"	483 mm
Weight	3300 lbs.	1500 kg
Skidder power requirements	80-90 hp	60-70 kw

FEATURES:

-Two double mattock rotary assemblies (mattock wheels). Each assembly incorporates four double mattocks made from wear-resistant steel alloys. Replaceable mattock tips are available at additional cost.

-Each mattock wheel incorporates a hydraulic cylinder complete with self-contained oil, pressure relief valve, and a cam and lever arrangement which secures sets of mattocks in "digging" mode. When timer (in vehicle's cab) has completed its cycle, the cylinder arrangements unlock the digging mattocks and the skidder's forward motion causes the mattock wheels to rotate a quarter-turn, positioning and

locking the succeeding mattocks in digging mode. The cycle is then repeated, creating scarified patches.

-The main frame which fixes each mattock wheel assembly at 5'-10" (1778 mm) center to center through a pivot at the bottom and by means of a heavy-duty rubber shock absorber at the top.

-A telescopic drawbar and universal-joint type hitch. The drawbar is integral with the frame; the hitch is bolted to the skidder.

During operation, the drawbar is fully extended as the skidder pulls the Patch Scarifier. The hitch allows the scarifier assem-

bly to move up, down and rotate as necessary to follow the contours of the terrain.

The skidder's winch can lift the Patch Scarifier to "transport" mode, as required. The drawbar retracts and automatically locks to prevent inadvertent rotation.

-Shock absorbers are incorporated between mattock wheels and the main frame, as mentioned above. Moreover, the telescopic drawbar contains a rugged, adjustable shock absorbing device which prevents excessive backlash, protecting the operator, skidder and Patch Scarifier against brutal shocks when the mattocks encounter hard-to-move obstructions.



Member
Belolt
Group

RADER CANADA LTEE/LTD.
C.P./P.O. BOX 925, SAINT LAURENT
MONTREAL, QUE., CANADA H4L 4W3
TELEPHONE (514) 331-1200 TELEX 05-824609

Rader Mechanical Disc Trencher

FEATURES:

- Two dished discs, each incorporating ten digging teeth, made from wear-resistant steel alloys.

Each disc free-wheels on anti-friction bearings with its axis tilted 30 degrees from the horizontal plane. This assembly, in turn, is fixed in a vertical housing which can be rotated through nine stepped positions to present a wider or narrower work face. This is accomplished simply by pulling two pins, turning the assembly to the position required, and re-inserting the pins.

-A universal joint type hitch which bolt-connects the Mechanical Disc Trencher to the skidder. The hitch allows the disc trencher to move up or down and rotate, as necessary, to follow the contours of the terrain.

When not in use, the skidder's winch lifts the Mechanical Disc Trencher off the ground to "transport" mode.

-The Mechanical Disc Trencher can be supplied with a quick-disconnect coupling as an option. This device enables the vehicle's operator to disconnect the skidder from the disc trencher by paying out cable from the skidder's winch as he drives to a more favourable location. He then winches the disc trencher to the stationary skidder until the quick-disconnect coupling is once more fully engaged. This option is especially valuable where severe conditions are likely to be encountered- such as swampy areas, steep slopes and sites with large quantities of debris, boulders, tree stumps or other heavy obstacles.

SPECIFICATIONS:

<i>Description</i>	<i>English</i>	<i>Metric</i>
Overall length	10'-0"	3050 mm
Overall width	11'-2"	3400 mm
Overall height	5'-4½"	1640 mm
Center to center of discs' vertical pivots	5'-0"	1525 mm
Disc outside diameter	4'-3"	1295 mm
No. of teeth per disc and length	10-11"	10-280mm
Disc assemblies' cant	30 degrees to horizontal	30 degrees to horizontal
*Disc assemblies face adjustment	9 positions	9 positions
*Furrow spacing (center to center)	Approx. 6'-4"	Approx. 2 M
Ground clearance (frame bottom to disc tip)	3'-2"	965 mm
Weight (Disc Trencher)	4145 lbs.	1880 kg
*Maximum weight (Disc Trencher + ballast)	6145 lbs.	2790 kg
Skidder power requirements	120 hp min.	90 kw min.

*By rotating disc assemblies, a narrower or wider working face is achieved. This will result in closer or wider furrow spacing during operation as well as shallower or deeper furrows (also, the heavier the assembly, the deeper the furrows).

- The main frame which incorporates a "weight box" with a hinged lid. This container is large enough to accommodate up to 2000 lbs. (910 kg) of dense material such as cast iron, steel, concrete or even stones from the

site. It is, of course important to vary the weight of the disc trencher, since it must dig shallow or deep furrows, depending on ground conditions in order to expose mineral soil for subsequent planting or seeding.



Member
Beloit
Group

RADER CANADA LTEE/LTD.
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MONTREAL, QUE., CANADA H4L 4W3
TELEPHONE (514) 331-1200 TELEX 05-824609

Mechanical Disc Trencher

 M8315

Rader



The Rader Model EQ-402 Mechanical Disc Trencher is a low cost, rugged and highly versatile piece of equipment for forest site preparation. It has been used successfully in areas covered with stumps, rocks, debris and duff as well as extremely hilly terrain. It is especially valuable for sites that are poorly drained or have a high water table since the furrows collect excess water

while the mounds offer mineral soil mulched with humus to plant seedlings or seeds.

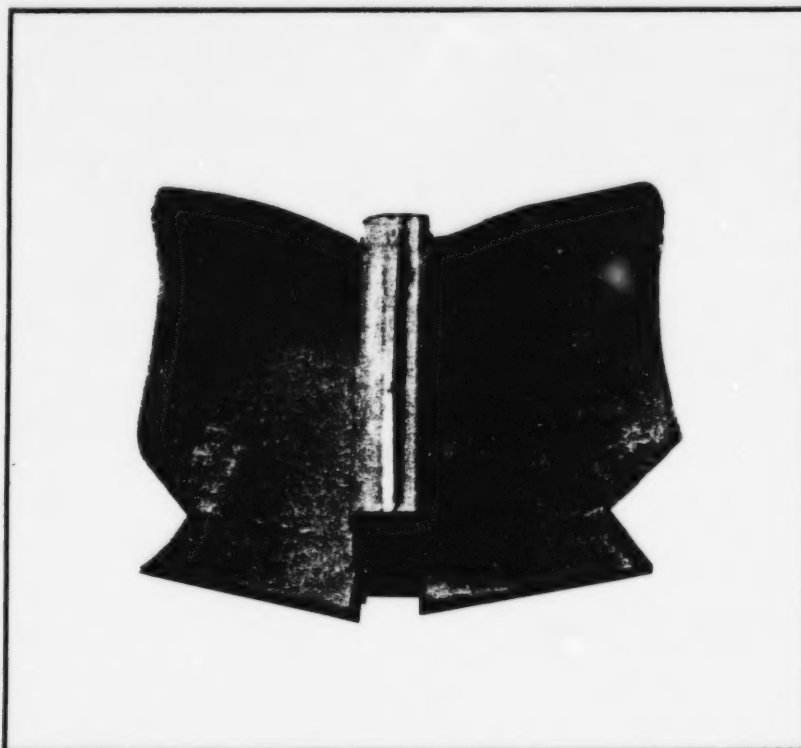
The Mechanical Disc Trencher, attached to a skidder, creates two continuous furrows, approximately 6'-0" (2 meters) apart, simultaneously.

On-site adjustments can be made quickly to suit different terrain conditions. Row spac-

ing, furrow width and depth of discs' penetration can all be varied somewhat. The rotary disc assemblies can be moved through nine positions to present wider or narrower digging faces; the main frame incorporates a container with a hinged lid which is large enough to accommodate up to 2000 lbs. (910 kg) of dense material, to provide additional weight.

Ripper Tooth Plow

 M8318



FEATURES:

- Unit measures 4'-0" (1015 mm) wide x 1'-9" (530 mm) deep x 2'-3" (585 mm) high. Ripper blades are replaceable and measure 4" x 20" x 1" thick (100 mm x 510 mm x 25 mm thick).
- Total weight: 1200 lbs.
- Crawler power requirements: 220 hp to 310 hp.
- Scarifies through duff which is too deep for other equipment.
- Effective in frozen ground (for winter use).
- Prepares sites which are inaccessible to other equipment.
- Modest initial investment and low maintenance requirements.

The Rader Model EQ-601 Ripper Tooth Plow, when installed at the back of a crawler type tractor, combines with the tractor's ripper shank to form an integral unit.

Because the Ripper Tooth effectively punches through frozen ground, this type of plow is used extensively during the winter months to treat swampy areas which cannot support the weight of heavy equipment until frost solidifies the soil.

In warmer weather, this is an excellent tool for use on sites with heavy sod covered with

slash. The Ripper Tooth Plow provides good mixing of wet or dry soils while breaking and spreading debris, allowing it to decompose without windrowing or collecting.

The tractor operator can control the depth and width of cut simply by varying hydraulic pressure. Hills can be contoured and furrows interrupted to prevent channeling water run-off. Mounds on each side of the swath cut by the plow remain above the high water table (which often develops after logging).

Seedlings, planted at the base of these mounds, are protected from drying surface winds and water ponding while root development is promoted by the loose mineral soil mixed with humus.

Site preparation with the Rader Ripper Tooth Plow makes use of the whole site for tree production, encourages water percolation and increases available soil moisture. This ensures a high survival rate of healthy trees in terrain which would otherwise be marginal for tree regeneration.

**Member
Beloit
Group**

RADER CANADA LTEE/LTD.
C.P./P.O. BOX 925, SAINT LAURENT
MONTREAL, QUE., CANADA H4L 4W3
TELEPHONE (514) 331-1200 TELEX 05-824609

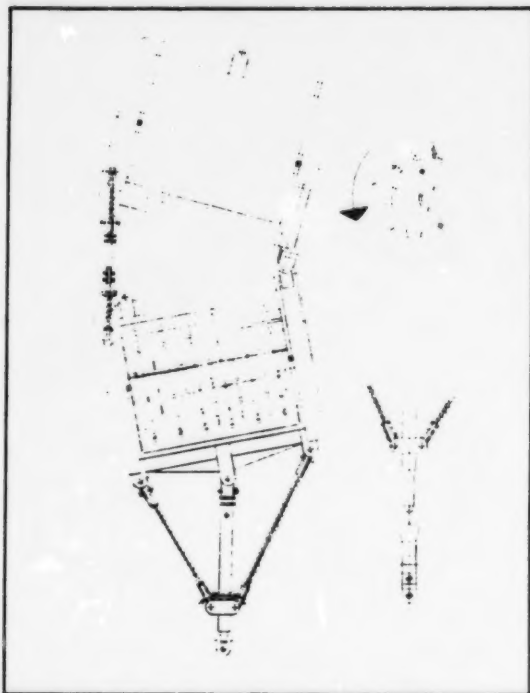


Figure 1 - Tandem Operation

FEATURES:

EFFICIENT Shears vegetation and scarifies soil effectively using alternate "wide" and "narrow" blades for excellent cutting, digging and mixing action.

ECONOMICAL Blades are reversible. When excessive wear or minor damage begins to affect operation, simply turn the blades 180 degrees to present a new working edge.

CONVENIENT The Brush Cutter & Cultivator Assembly can be hooked up and detached from the tractor using only one man - the driver!

The "quick-disconnect" hitch, when incorporated, allows the tractor to be disengaged instantly and manoeuvred independently from the Brush Cutter & Cultivator Assembly. This feature is very useful when tractor is in danger of bogging down or when large obstacles are encountered. The tractor is moved to solid ground and the Brush Cutter & Cultivator Assembly are winched back together - all in a matter of minutes! (See bulletin M8312 for full details on how this hitch works.)

VERSATILE The rollers can be used empty or water-filled so that weight will match the vegetation, soil and site conditions.

The same unit can be operated in either tandem or duplex mode making it suitable for cut-over, burned or scrub-covered forest as well as abandoned farm land. It's effective in almost any terrain!

STANDARDIZED This unit is manufactured in three standard sizes. This range effectively covers most requirements. Special units can be considered when existing tractor limitations, site sizes and conditions warrant custom-sizing.

JOB PROVEN Units now in operation in Eastern Canada (Newfoundland, New Brunswick, Quebec and Ontario) have proven to be rugged and reliable.

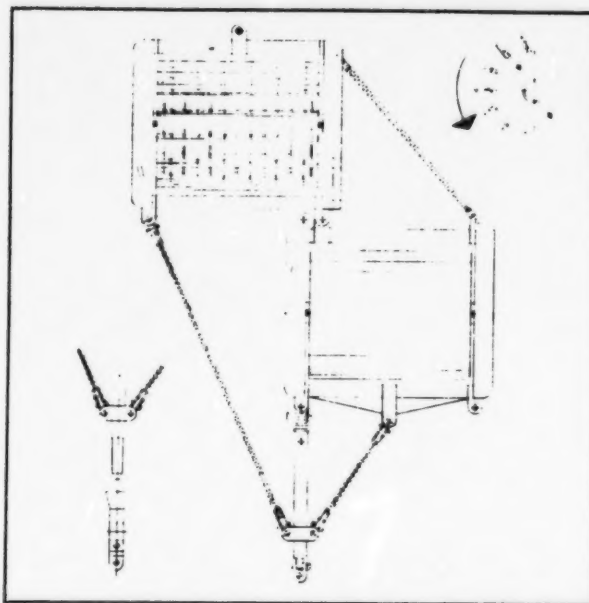


Figure 2 - Duplex Operation

SPECIFICATIONS:

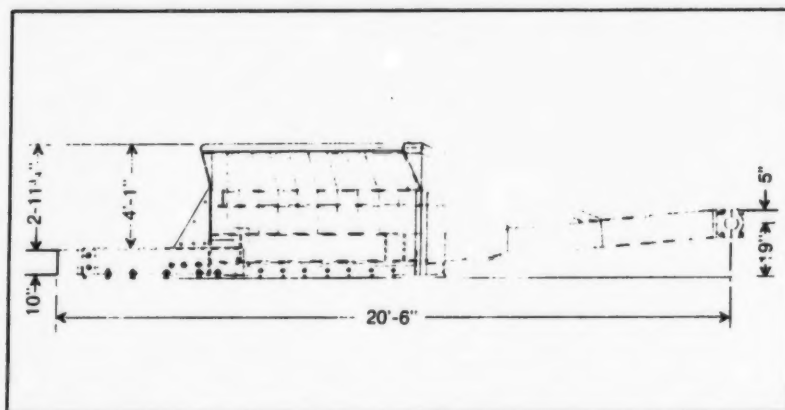
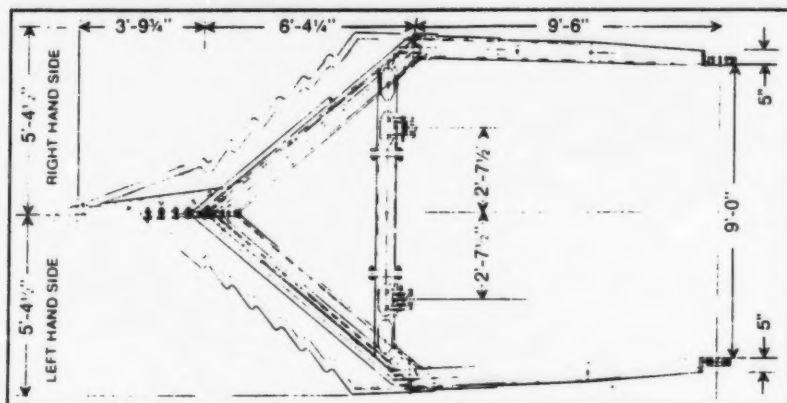
Description	Model No. EQ-501	Model No. EQ-502	Model No. EQ-503
Number of rollers	2	2	2
Overall diameter (including blades)	5'-7" (170 cm)	6'-9" (206 cm)	6'-9" (206 cm)
Roller diameter	3'-7" (109 cm)	4'-9" (145 cm)	4'-9" (145 cm)
Roller length	7'-0" (214 cm)	8'-0" (244 cm)	10'-0" (305 cm)
Blade spacing (At outer edge)	1'-6" (46 cm)	1'-6" (46 cm)	1'-6" (46 cm)
Wide blade (quantity and dimensions per roller)	10" x 1" 6-(254 mm x 25 mm)	10" x 1" 7-(254 mm x 25 mm)	10" x 1" 7-(254 mm x 25 mm)
Narrow blade (quantity and dimen- sions per roller)	8" x 1/4" 6-(203 mm x 19 mm)	8" x 1/4" 7-(203 mm x 19 mm)	8" x 1/4" 7-(203 mm x 19 mm)
Ground penetration	Up to 11" (280 mm)	Up to 11" (280 mm)	Up to 11" (280 mm)
Tractor attachment type	Draw bar*	Draw bar*	Draw bar*
Tractor power requirements	220 HP	310 HP	380 HP- 410-HP
Total weight, empty	18,000 lbs. (8,165 kg)	32,000 lbs. (14,515 kg)	35,000 lbs. (15,875 kg)
Total weight, water filled	27,000 lbs. (12,250 kg)	49,000 lbs. (22,225 kg)	56,000 lbs. (25,400 kg)
Water capacity (2-rollers)	840 Imp.gal. (3815 liters)	1710 Imp.gal. (7750 liters)	2135 Imp.gal. (9700 liters)

*Quick-disconnect tractor attachment is available at extra cost. See bulletin M-8312 for full description.



RADER CANADA LTEE/LTD
C.P./P.O. BOX 925, VILLE SAINT LAURENT
MONTREAL, QUE., CANADA H4L 4W3
TELEPHONE (514) 331-1200
TELEX 05-824609

Rader



FEATURES:

- Four sizes available to suit your crawler type tractor.
- Replaceable stinger and scalping blades available.
- Effective in preparing sites for seeding or planting.
- Fast return on modest initial investment.
- Can be used to clear paths through wooded areas and build roads, quickly.

The Rader Series EQ-1001 Shark Plow is a specialized V-Blade incorporating a long, robust "Stinger" which can split tree stumps in addition to breaking the surface of the ground. Shark Toothed (serrated) scalping blades complete the removal of duff and also shear off the remains of stumps. The V-Blade pushes the duff, rocks, stumps and uprooted small vegetation to both sides, leaving a clear path in the tractor's wake. Seeding or tree planting can then be effected in the cleared path.

The Shark Plow is also a most effective tool for clearing paths through dense woods so that trails and roads can be built quickly. Unlike tractors equipped with normal blades, there is no build-up of material in front of the tractor so that there is no need to stop, back up and dump to the side.

Normally, the Rader Shark Plow is supplied with "weld-on" Shear Blades and Stinger. It can also be supplied with bolt-on, replaceable Shear Blades and Stinger at a modest additional price. Four models are available in the EQ-1001 series to suit the various crawler type tractors on the market. Full details on the size to suit your tractor can be provided upon receipt of particulars regarding your equipment.



Member
Beloit
Group

RADER CANADA LTEE/LTD.
C.P./P.O. BOX 925, SAINT LAURENT
MONTREAL, QUE., CANADA H4L 4W3
TELEPHONE (514) 331-1200 TELEX 05-824609

Rader V-Plow (C.F.S.)

ADJUSTMENTS*

- The bracket which attaches the V-Plow to the tractor's "C" frame can be mounted to the V-Plow in any one of four vertical mounting positions, or through a total range of 12" (305 mm), to suit almost any tractor.

- The scalper plates have a two-position adjustment possib-

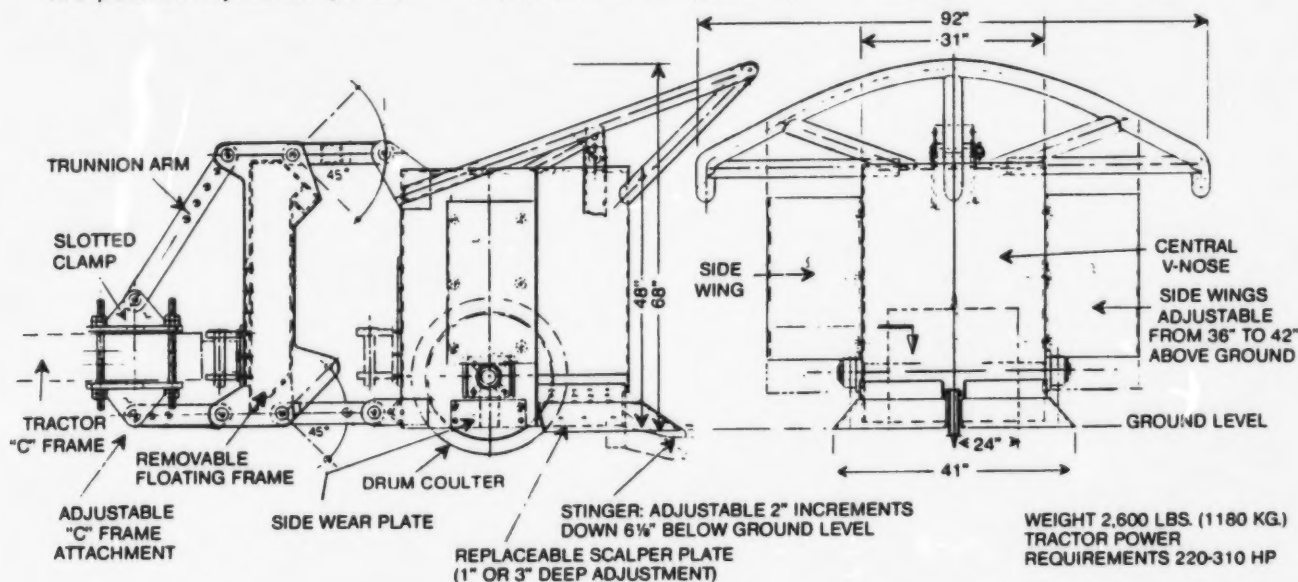
ility; either 1" (25 mm) or 3" (76 mm) below ground level.

- The Stinger can be adjusted vertically through a range of 6" (150 mm), in two-inch (50 mm) increments.

- Side wings can be positioned to clear ground level by either 6" (150 mm) or 12" (305 mm).

Since R.H. and L. H. wings are identical, they can be interchanged once worn. This approximately doubles effective life.

* Stinger can be adjusted rapidly by pulling and re-inserting one pin; all other adjustments are effected by removing bolts, relocating attachment(s) and re-bolting.



OPTIONAL ATTACHMENT - MODEL EQ-801 FLOATING FRAME

The Rader "Floating Frame" adds a further dimension to make the Rader Model EQ-301 V-Plow even more versatile and effective - especially where terrain is hilly or bumpy and where large amounts of high tree stumps, rocks or other bulky debris are likely to be encountered.

The Floating Frame is incorporated between the tractor "C" frame and the Rader V-Plow, allowing it to swivel up to 45 degrees, upwards or downwards, independently from the tractor's attitude. (See our drawing above which shows the Floating Frame in place).

It prevents the V-Plow from digging too deeply or being lifted from the ground when the tractor runs over stumps, rocks or uneven terrain.

The Model EQ-801 Floating Frame gives you better results, in less time, in return for a modest investment!



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MONTREAL, QUE., CANADA H4L 4W3
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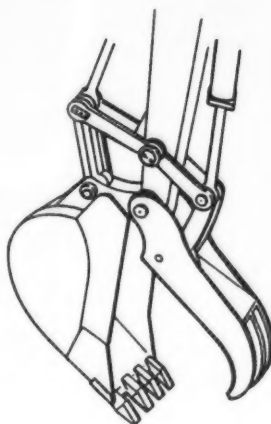
APPENDIX V. WELDCO-BEALES LTD.



BUCKET CLAMP (LINK STYLE)

Innovative link design allows effective clamping in all bucket positions. When not in use, the link permits the clamp to be folded back against the stick, enabling full utilization of the bucket. Custom designed for most excavators.

MACHINE SIZE	MODEL	WIDTH	LENGTH	APPROX. WEIGHT LBS.
1/4 yd.	B C 03	To Suit Bucket Width	To Match With Bucket Teeth	315
3/8 to 1/2 yd.	B C 04			450
1/2 yd.	B C 05			480
5/8 to 3/4 yd.	15 B C 1 5			975
1 to 1-1/4 yd.	25 B C 2			1200
1-3/8 to 1-3/4 yd.	35 B C 2 5			1975
1-7/8 to 2-1/2 yd.	45 B C 3			2500

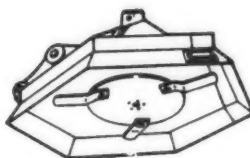


Auxiliary hydraulic control valve is required.
Pressure relief valve must be installed in circuit.

BRUSH CUTTER

For maintaining logging and rural roads, bridge approaches, railway grades, and power line right-of-ways. Allows cutting within 5" of obstacles. Cuts and sneds brush and trees up to 6" in diameter. Heavy duty coupling, bearings and cutter used.

MACHINE SIZE	MODEL	WIDTH OF CUT	GAL/MIN REQUIRE	PRESSURE P.S.I.	WEIGHT LBS.
3/8 to 5/8 yd.	10-RF	36"	26	1000	550
5/8 to 3/4 yd.	15-RF 25-RF	52"	40	1800	1400
1-1/4 to 1-5/8 yd.	35-RF	60"	45	2100	1800

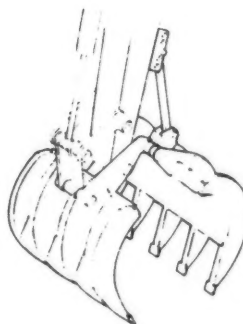


EXCAVATOR BRUSH RAKE

Raking stumping, handling bulky materials. Designed for loggers and contractors for grubbing and clearing needs.

Optional:
Hydraulic cylinder kit allows full control of rake bottom (extra valve required).

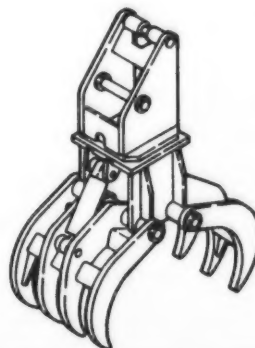
MACHINE SIZE	MODEL	OPEN	CLOSED	WIDTH	WEIGHT LBS.
1/4 to 3/4 yd.	15 BR 2	96"	12"	36"	2150
1 to 1-1/4 yd.	25 BR 3	110"	15"	48"	3000
1-3/8 to 1-3/4 yd.	35 BR 4	128"	18"	54"	3625
1-7/8 to 2-1/2 yd.	45 BR 5	140"	20"	54"	4450



POWER CLEARING RAKE

Same dexterity as power grapple, allowing operator to land clear, build a burning pile, load logs, etc.

MACHINE SIZE	MODEL	OPENING	CLOSING	WIDTH	WEIGHT LBS.
1 to 1-1/4 yd.	25-PR-45	45"	6"	36"	3300
1-3/8 to 1-3/4 yd.	35-PR-54	54"	14"	42"	4100



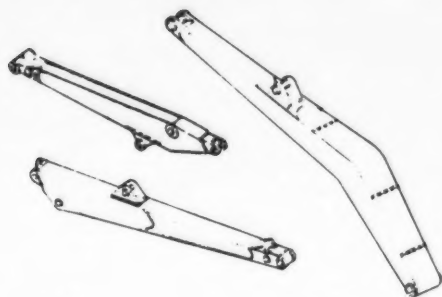
WELDCO

EXCAVATOR ATTACHMENTS I



WELDCO

EXCAVATOR ATTACHMENTS II

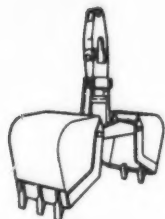


Need a Longer Stick? Jib Boom? Stick Extension?
Ask Weldco.

How about a Special Boom? Solve the problem with
more Lift or Digging Ability.

Weldco's Design Engineering Group has created many
proven solutions for application problems - your prob-
lem may already be solved.

See Specification Sheet No. 77 for more information.



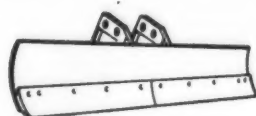
Clam shell, designed for the logger who needs to cast, trim banks, handle
logs and stumps. Both styles available with or without 360° power rotation.

MACHINE SIZE	MODEL	CAPACITY	WIDTH	WEIGHT
60 TO 80,000 LBS	PCSB/D32 PCSB/D47	7/8 YD 1 YD	72" 87"	4,325 4,624

MACHINE SIZE	MODEL	CAPACITY	WIDTH	WEIGHT
85 TO 125,000 LBS	PCSBH/47 PCSBH/68	1 1/8 YD 1 1/4 YD	87" 98"	4,750 5,500

GRADING AND BACKFILLING BLADES

An added feature if combined with a Weldco Kwik-A-Tach System, will
allow changing from bucket to blade in minutes.



MACHINE SIZE	MODEL	HEIGHT	WIDTH	WEIGHT
14 TO 22,000 LBS	EGB5	12"	72"	800
24 TO 35,000 LBS	EGB15A	14"	96"	1,050

MACHINE SIZE	MODEL	HEIGHT	WIDTH	WEIGHT
40 TO 55,000 LBS	EGB25B	16"	96"	1,050
60 TO 80,000 LBS	EGB35C	18"	96"	1,200
85 TO 130,000 LBS	EGB45D	20"	108"	1,800

RIPPER TOOTH

An ideal tool for ripping through rock and perma frost. It has a replaceable
point and is available with swivel head or Kwik-A-Tach system.

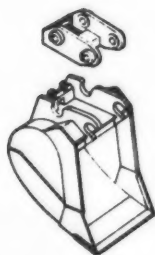


MACHINE SIZE	MODEL	TOOTH PENETRATION	WEIGHT
15 TO 22,000 LBS	ERT5A	18"	475
25 TO 35,000 LBS	ERT15B	24"	550

MACHINE SIZE	MODEL	TOOTH PENETRATION	WEIGHT
40 TO 55,000 LBS	ERT25C	24"	625
60 TO 80,000 LBS	ERT35D	28"	1,275
85 TO 130,000 LBS	ERT45E	36"	1,900

KWIK-A-TACH COUPLER

Increases the versatility of every excavator, allowing the change of buckets,
etc., in minutes. Adaptable to all attachments. A wedge locks all implements
securely into position, eliminating expensive manual change-overs. Operators
appreciating the ease and speed of the Kwik-A-Tach will make use of this
valuable attachment.



MACHINE SIZE	MODEL	WEIGHT
25 TO 35,000 LBS	EKC15	210

MACHINE SIZE	MODEL	WEIGHT
40 TO 55,000 LBS	EKC25	250

MACHINE SIZE	MODEL	WEIGHT
60 TO 85,000 LBS	EKC35	315

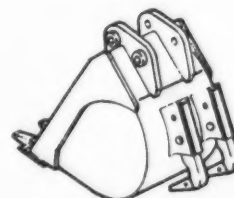
BACKHOE RIPPER BOXES

Increase digging ability in tough conditions. Four sizes
available from 3/4 yd. to 3 yd. excavators. Welds onto
back of Bucket.



MACHINE SIZE	MODEL	WEIGHT
15 - 22 LBS	ERB 5A	100 LBS
25 - 35 LBS	ERB15B	185 LBS

MACHINE SIZE	MODEL	WEIGHT
40 - 50 LBS	ERB25C	215 LBS
60 - 80 LBS	ERB35D	390 LBS
85 - 130 LBS	ERB45E	410 LBS



If you don't see it listed, that doesn't mean we don't build it.

Refer to Specification Sheet No. 49A for Hydraulic and 360 Degree Rotating Excavator Attachments.

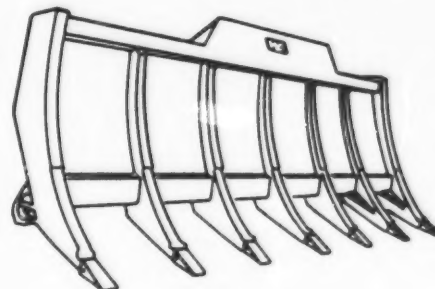


ATTACHMENT SPECIALISTS

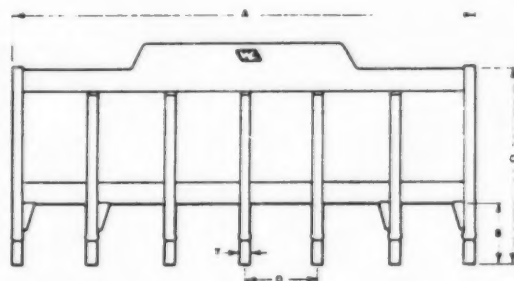
LAND CLEARING BLADE - "C" Frame or Straight Dozer.

The Straight Blades are designed to mount interchangeably with the standard dozer blade, while the "C" Frame model comes complete with sidearms. No centre pin required, allowing for quick and easy mounting.

			BLADE INFORMATION					
TRACTOR MODEL NO	ATTACHMENT CLASS NO	BLADE MODEL NO	LENGTH (A)	TOOTH PENETRATION (B)	FRAME HEIGHT (C)	TOOTH SPACING (D)	TOOTH THICKNESS (E)	APPROX WEIGHT
D3 TD 7 - 8 D20 JD 150 450 Cater 350 450	110	CBB2	88	12	41	15	1 1/2	1100
		SBB2	92	12	43	16	1 1/2	1100
D4 TD4 FA4C (Cater 450) D550	160	CBB3	107	18	41	21	2	1500
		SBB3	99	18	41	18 3/4	2	1650
D35 190 1150	185	CBB4	123	18	46	20	2	1900
		SBB4	112	18	46	17 1/2	2	2000
D5 DB 1015 FA10 1440 D55 86 JD 190	195 210	CBB5	126	18	49	21	2 1/2	2050
		SBB5	119	18	49	17	2 1/2	2000
D6A FA12 1440	210	CBB6	144	18	49	24	2 1/2	2950
		SBB6	129	18	49	21	2 1/2	3000
D6C TD 200 D6144 6220 FA 14	210	CBB7	139	18	49	22 3/4	2 1/2	2750
		SBB7	129	18	49	21	2 1/2	3500
D6E 2	210	CBB8	150	18 3/4	54	24 3/4	2 1/2	3900
		SBB8	148	18 3/4	54	22 1/2	2 1/2	3950
D6E 1100 D120 FA 21 62 408 1100	220	CBB9	148	21	57	20 3/4	3	3600
		SBB9	148	21	57	20 3/4	3	3600
D6E D125 R2 121 FA 11 125	230	CBB10	177	22 3/4	68	21 1/4	3 1/2	4500
		SBB10	157	22 3/4	68	22	3 1/2	4600
D6A FA41 D355	230	CBB11	180	23 1/2	77	23	4	12000
		SBB11	167	23 1/2	77	23	4	14000



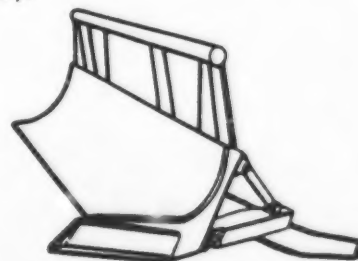
CBB - "C" Frame Clearing Blade
SBB - Straight Land Clearing Blade



All blades are designed for greater wear resistance and longer life through custom engineering. Special Rock Rakes available on request. Additional teeth may be installed at additional cost. Special blades are available for LGP machines. For custom designs consult factory. Specifications subject to change without notice or prior commitment.

ONE WAY BRUSH CUTTERS

- 3 models, all with built in splitter.
- Serrated or straight edge.
- Optional heavy duty bumper.
- Supplied with rigid struts for C-frame mounting.





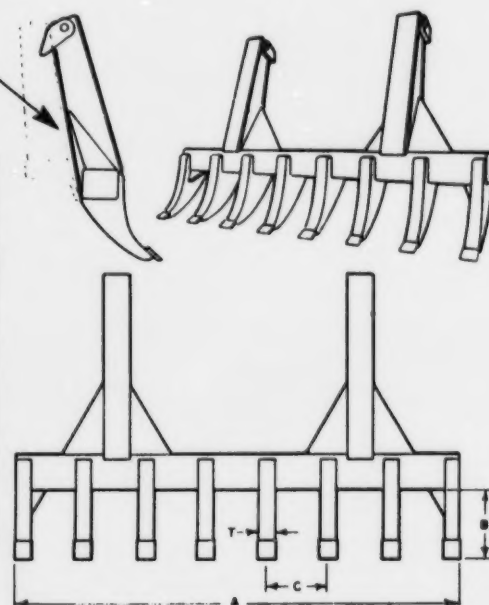
LAND CLEARING ATTACHMENTS

Bulldozer Blade

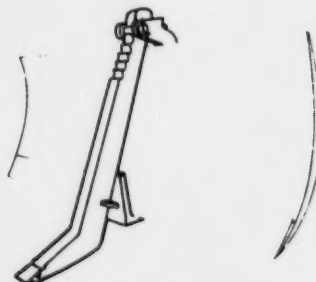
MOLD BOARD RAKE - Designed for small brush removal and land clearing. Once the weld-on brackets are installed, the rake may be removed or reinstalled in a few minutes.

TRACTOR MODEL NO.	ATTACHMENT CLASS NO.	MOLD BOARD MODEL NO.	MOLD BOARD RAKE INFORMATION				
			RAKE LENGTH (A)	TOOTH PENETRATION (B)	TOOTH SPACING (C)	TOOTH THICKNESS (T)	APPROX WEIGHT
D3 100 - 14 D20 (D34-350 Cater 350-450)	110	MBR2	72	14 7/8	14	1 1/2	670
D4 100 140 (Cater 190) JL440	110	MBR3	84	15 1/4	16 1/2	1 1/2	850
D40, 50, 1150 140, 140 (140) 140 (140) 140, 140 (140)	110	MBR4	100	16 3/4	16 3/8	2	1250
D40, 140 (140) D40, 140 (140) D40, 140 (140)	110	MBR5	108	18 3/4	15	2 1/2	2050
D40, 140 (140) D40, 140 (140) D40, 140 (140)	110	MBR6	120	20 3/4	16 3/4	3	2800

Special Lengths on Request.



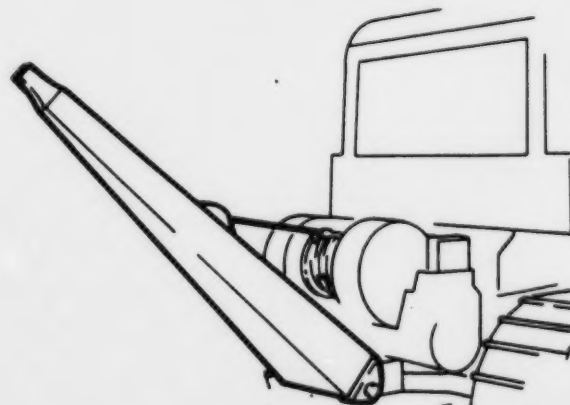
TRACTOR MODEL NO.	TOOTH MODEL NO.	FITS DOZER BLADE HEIGHT (A)	DIGGING DEPTH (B)	TOOTH THICKNESS (T)	APPROX WEIGHT
D3 100 - 14 D20 (D34-350 Cater 350-450)	DRT 2	20" to 23"	10	1 1/2	55
D4 100 140 (Cater 190) JL440	DRT 3	24" to 34"	13	2	100
D40, 50, 1150 140, 140 (140) 140 (140) 140, 140 (140)	DRT 4	30" to 40"	15	2	195
D40, 140 (140) D40, 140 (140) D40, 140 (140)	DRT 5	36" to 46"	17	2 1/2	335
D40, 140 (140) D40, 140 (140) D40, 140 (140)	DRT 6	42" to 52"	20	3	515



DETACHABLE RAKE TOOTH - A rugged low cost ripping tool which may be mounted on any dozer blade within minutes, by one man.

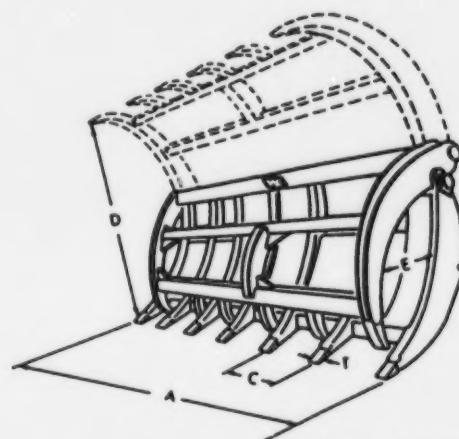
STUMP SPLITTERS - For Hyster, Carco and Caterpillar. Winches also available to adapt to any Ripper tool bar. Hydraulic operation available when no winch is required.

TRACTOR MODEL	ATTACHMENT CLASS NO.	MODEL	SPLITTER LENGTH	APPROXIMATE WEIGHT
D4/D6	175/235	SS2	108"	1750 lb
D7/D8	280/390	SS3	90"	2100 lb



GRAPPLE RAKE - Versatile in its application and built to last, the Grapple Rake reduces time and energy in land clearing operations. With this attachment, the operator can quickly stack, load and remove logs and boulders with ease. Also recommended for feeding small logs, brush and slash to chipper.

LOADER CLASS NO.	GRAPPLE RAKE MODEL NO.	GRAPPLE RAKE INFORMATION						
		GRAPPLE LENGTH (ft.)	TOOTH SPACING (in.)	TOOTH WIDTH (in.)	TOOTH HEIGHT (in.)	MAX. CAPACITY (cu. yd.)	WEIGHT (lb.)	MAX. HEIGHT (ft.)
ND	GR 2	72	12	14	1-1/2	72	15	2000
150	GR 3	95-1/4	15-1/4	18-3/4	1-1/2	78	15	3300
200	GR 4	106	16	17	2	85	19	4300
250	GR 5	117-1/2	18-3/4	19-1/4	2	89	19	5200
300	GR 6	128-1/2	18-3/4	21	2 1/2	97	20	7000

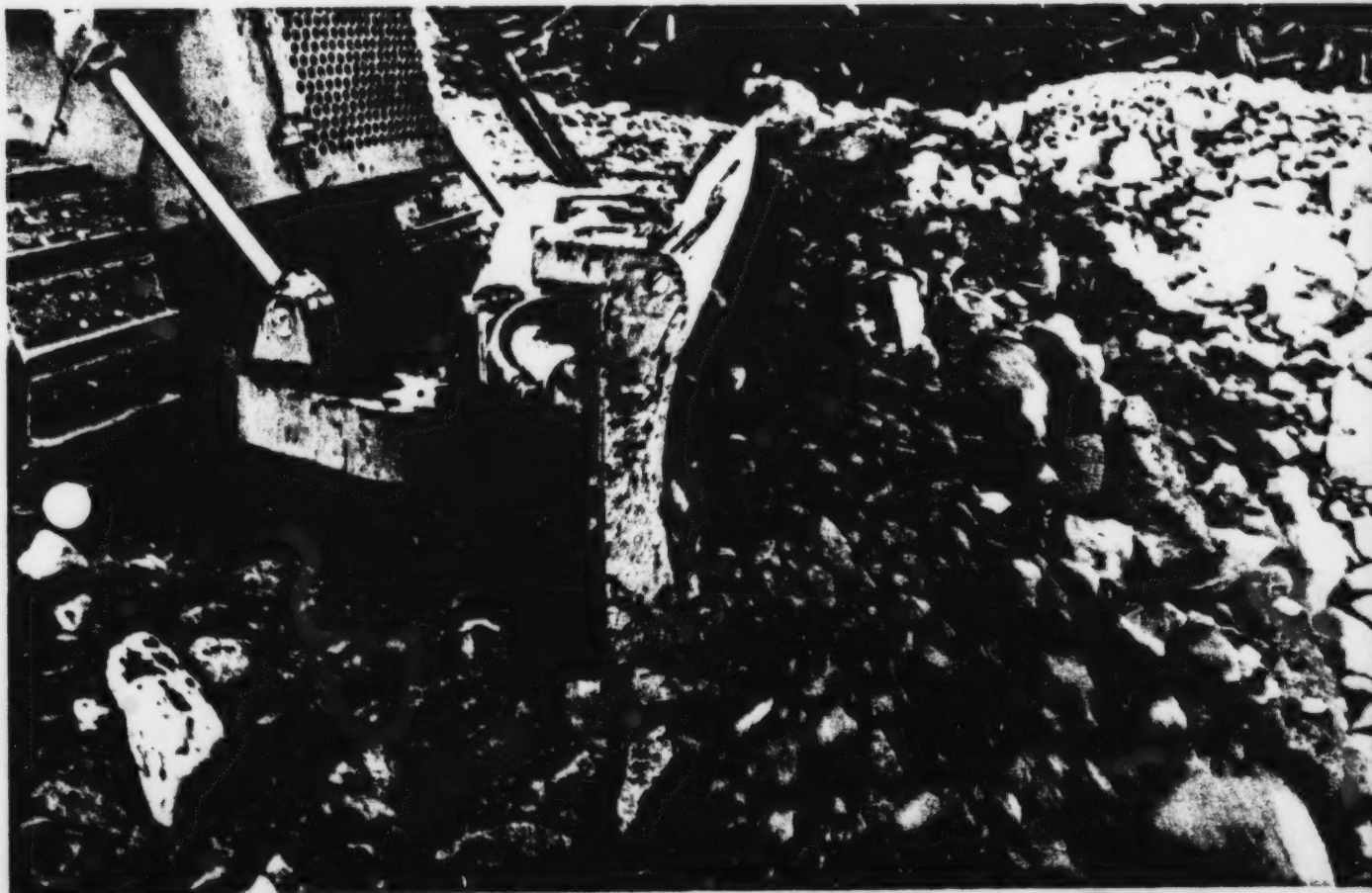


GR5 MODEL SHOWN ABOVE

STACKING RAKES AVAILABLE WITHOUT TOP CLAMP ASSEMBLY.

WELDCO-BEALES
Equipment Manufacturers and Designers

Weldco-Beales
Six-Way
All Hydraulic Blade



APPENDIX VI. LIST OF SURVEY CONTACTS

APPENDIX VI. LIST OF SURVEY CONTACTS

FOREST INDUSTRY AND CONTRACTORS

Basaraba, Dave	Crestbrook For. Ind.	Cranbrook
Boudreau, Wayne	Quest Wood For. Prod.	Quesnel
Burkholder, Richard	Westar Timber	Vanderhoof
Butt, Gordon	Soil Scientist	Shawnigan Lake
Diedrickson, Fred	Arboress Enterpr. Ltd.	Prince George
Donkersley, Ken	CIP, Tahsis Pacific	Saanich
Fulbrook, Jim	Fulbrook Contracting	Vernon
Gellings John	Gellings Enterprises	Fort St. John
Harwijne, John	Crown Forest Ind. Ltd.	Courtenay
Hedin, Ingrid	FERIC	Vancouver
Irving, Tom	For. Ind. Flying Tankrs.	Port Alberni
McCutcheon, Brian	CIP, Tahsis Pacific	Gold River
McNabb, Lyle	Houston For. Prod. Ltd.	Houston
Peaker, Dennis	Weyerhaeuser Canada	Okanagan Falls
Phillips, Pat	MacMillan Bloedel	Northwest Bay
Ryans, Mark	FERIC	Pointe Claire
Skjerpen, Dennis	Evans Products	Savona
Smith, Tim	Northwood Pulp & Tbr.	Houston
Todd, Al	Integr. Silv. Serv.(ISS)	Prince George
Tuttle, Wayne	Contractor	Fort St. John
Van Oosten, Cees	MacMillan Bloedel	Kelsey Bay
Walker, Brian	Fraser Lake Sawmills	Fraser Lake
Waters, Alan	West Fraser Mills	Quesnel

GOVERNMENT

Bedford, Lorne	BCMFL, Silv. Branch	Victoria
Connor, Mike	BCMFL, Pr. Geo. Region	Prince George
Dawson, Heather	BCMFL, Pr. Geo. W FD	Prince George
Fahlman, Rick	BCMFL, Pr. Geo. E FD	Prince George
Faliszewski, Mark	BCMFL, Kamloops Region	Kamloops
Fraser, Bruce	BCMFL, Nelson Region	Nelson
Johnson, Bob	BCMFL, Bulkley FD	Smithers
Lloyd, Gary	BCMFL, Pr. Rupert Reg.	Smithers
McNaughton, Brian	BCMFL, Nelson Region	Nelson
Mitchell, Warren	BCMFL, Cariboo Region	Williams Lake
Paver, Darby	Alberta For. Service	Slave Lake, Alta.
Pinkerton, Gerry	BCMFL, Pr. Rupert Reg.	Smithers
Przeczek, John	BCMFL, Cranbrook FD	Cranbrook
Randall, Al	BCMFL, Cariboo Region	Williams Lake
Renaud, Diane	BCMFL, Fort St. John FD	Fort St. John
Richenhaller, John	CFS, Gr. Lakes For. Ctr.	Sault St. Marie
Sigurdson, Larry	BCMFL, Vancouver Region	Vancouver
Trigg, Dirk	BCMFL, Horsefly FD	Horsefly
von Hahn, Charles	BCMFL, Vanderhoof FD	Vanderhoof
Williams, Bill	BCMFL, Pr. Geo. Region	Prince George
Yano, H. (Yo)	BCMFL, Kamloops Region	Kamloops

MANUFACTURERS AND SUPPLIERS

Bax, Herb	KBM Forestry Cons. Inc.	Thunder Bay, Ont.
Cazes, Lyall	Cazes & Heppner (C&H)	Abbotsford
Cox, Paul	Weldco-Beales	Langley
Duncan, Floyd	Rader Canada Ltd.	Vancouver
Fahrenholtz, Wayne	Kootenay Tractor Ltd.	Nelson
Fitzsimmons, Don	Weldco-Beales	Langley
King, Wally	Can. Forestry Eq. Ltd.	Edmonton, Alta.
Kukkonen, Erkki	Hakmet Ltd.	Dorion, Que.
Lavigne, Jean	Rader Canada Ltd.	Montreal, Que.
Sanders, Ron	H. E. Sanders Ltd.	Merritt
Siedelmann, Rick	Weldco-Beales	Langley